controldesign.com

control design

FOR MACHINE BUILDERS

15TH ANNIVERSARY

Mechanical **Motion Simplicity**

Flashback 2004: **Count on Software**

An **OEE Culture**

FAST MOVERS

Ethernet's Many Variants Are Just the Ticket for High-Speed Motion Applications. Get on Board With the One That Works Best for You

OCTOBER 2012

PutmanMedia®

EZ Series™ CE Touchpanels

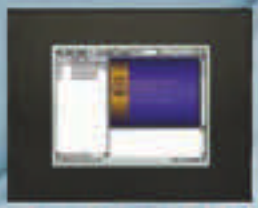
An HMI with Windows® PC features !!

Made In America

HMI Program Conversion available

CALL Factory for more details on converting HMI from current supplier.

View Video
View video file in MPEG format



View PowerPoint
Visually learn and train

View Excel
View and analyse current data

View PDF
View machine manuals in PDF format

Windows CE OS, Web Video

File Viewers such as Acrobat, Excel, Word, PowerPoint, Image and Internet Explorer

- Serial and Ethernet protocols built-in (AB Ethernet IP, Modbus TCP/IP, GE SRTP, Directlogix Ethernet)
- USB & Compact Flash for Data logging
- Troubleshoot your Panel/Project Half way across the World without leaving your Desk!!

EZTouch Product Line-up

1. Same Day Shipping until 7:15 PM CST
2. #1 Tech Support 6:00 AM to 12:00 Midnight
3. #1 Customer Service 6:00 AM to 7:00 PM CST

Request your FREE Catalog with OVER 400 Exciting new Products

Innovate'n'Save™

1-877-774-EASY
3279

www.EZAutomation.net

Process Measurement & Control

⅛ DIN Ultra High Performance Meter/Controller

- Universal Inputs: DC Voltage/Current, T/C, RTD, Strain
- Accuracy: ±0.005% rdg
- Up to 142 Readings Per Second
- 10 Point Linearization
- 4 Isolated Open Collector Output
- Isolated Analog Output Optional
- Four Relays Optional
- Ethernet or RS-232/RS-485 Optional
- NEMA 4 Front Bezel

Visit omega.com/dp41b

DP41-B Starts at $595

change color

at any setpoint or alarm point

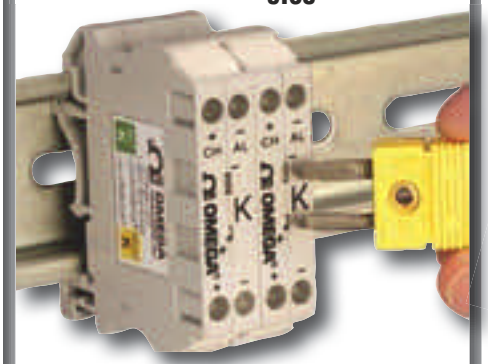
1/16 DIN MICROMEGA® Autotune PID Temperature/ Process Controllers

CN77000 Series Starts at $249

Visit omega.com/cn77000

Thermocouple Terminal Blocks with Audit Capable Female Connector

DRTB Series Starts at $9.50



Visit omega.com/drtb

Large Selection of Thermocouples

5LRTC Series Starts at $52

Visit omega.com/5lsc_5srtc

1-888-82-66342®
1-888-TC-OMEGA

omega.com

OMEGA®

All the Tools you Need for Embedded Measurements and Control,

in one rugged box.

- Graphical Software
- Sensor Connectivity
- Signal Analysis
- Control Algorithms
- Custom Timing
- Custom Triggering
- Actuator Connectivity
- Embedded Storage
- Industrial Networks
- Expansion Systems

The NI CompactRIO hardware platform can handle your embedded measurement and control applications, and do it in a way that outperforms other off-the-shelf systems so you don't have to spend time developing a custom solution. The range of high-quality measurements, coupled with an extremely rugged design and the ability to modify the hardware using NI LabVIEW system design software, gives you all the benefits of customization with the convenience of an off-the-shelf platform.

>> To learn more about CompactRIO, visit **ni.com/compactRIO**

800 891 2755

NATIONAL INSTRUMENTS™

FEATURES

COLUMNS

HOT BUTTONS

CONTROL DESIGN, (ISSN: 1094-3366) is published 12 times a year by Putman Media, 555 West Pierce Rd., Suite 301, Itasca, Illinois 60143. (Phone 630/467-1300; Fax 630/467-1124.) Periodical postage paid at Itasca, IL, and at additional mailing offices. Address all correspondence to Editorial and Executive Offices, same address. Printed in the United States.

POSTMASTER: Send address changes to Control Design, Post Office Box 3430, Northbrook, Illinois 60065-3430. SUBSCRIPTIONS: To apply for a free subscription, fill in the form at www.ControlDesign.com/subscribe-mag. To non-qualified subscribers in the Unites States and its possessions, subscriptions are $96.00 per year. Single copies are $15. International subscriptions are accepted at $200 (Airmail only.) Putman Media also publishes CHEMICAL PROCESSING, CONTROL, FOOD PROCESSING, INDUSTRIAL NETWORKING, PHARMACEUTICAL MANUFACTURING and PLANT SERVICES. CONTROL DESIGN assumes no responsibility for validity of claims in items reported. Canada Post International Publications Mail Product Sales Agreement No. 40028661. Canadian Mail Distributor information: World Distribution Services, Inc., Station A, PO Box 54, Windsor, Ontario, Canada N9A 6J5. Printed in the United States.

Why pay more for lower performance?

EtherCAT systems from Beckhoff are high speed, high performance – and – low cost!

PC-based Control with EtherCAT

- Solid state IPCs and PACs with integrated Ethernet ports; no need for network scanners
- Use software instead of hardware: PLC and Motion Control on one PC

EtherCAT I/O

- Real-time Ethernet down to each I/O module
- Large, cost-effective selection for all signal types

EtherCAT Drives

- Highly dynamic Servo Drives
- Integrated, ultra fast control technology

EtherCAT®

www.beckhoff.com/EtherCAT-System

Beckhoff EtherCAT components: Fast, flexible, precise and always cost-efficient

- Industrial PC: powerful PCs for any automation task
- EtherCAT Terminals: IP 20 I/O for all signal types
- EtherCAT Box: machine-mountable IP 67 I/O directly in the field
- TwinCAT: flexible automation software for multi-PLC, NC, CNC
- TwinSAFE: Safety PLC integrated into I/O terminals

IPC
I/O
Motion
Automation

New Automation Technology **BECKHOFF**

NEW WHITE PAPERS

REDUCE ARC ENERGIES WITH CURRENT-LIMITING FUSES
This paper illustrates the reduction of incident heat energy and the associated flash hazard boundary.

EXTEND INDUSTRIAL RELIABILITY TO CONTROL ROOMS
Find out why networks are more vulnerable in the control room than at field sites.

CELLULAR RTU TECHNOLOGY FOR REMOTE PIPELINES
Understand how to face the technical challenges inherent in remote data acquisition.

UNLOCK AUTOMATION SYSTEMS FOR HIGHER BUSINESS RESPONSIVENESS
Learn how integrating MES with control systems makes manufacturing more agile.

To download PDF papers, go to ControlDesign.com/whitepapers.

SPECIAL TO THE WEB

IMTS 2012'S MACHINE BUILDERS TAKE OVER CHICAGO
www.ControlDesign.com/montagueimts

IS SOCIAL MEDIA A USEFUL TOOL OR WASTE OF TIME?
www.ControlDesign.com/social

RIDE THE PLC VS. PC TIME MACHINE
www.ControlDesign.com/time

LATINO INVOLVEMENT IN STEM
www.ControlDesign.com/latino

FINDING A PLACE FOR TECHNICIANS
www.ControlDesign.com/technicians

Machines That Go Boo!

THIS MONTH, MANY of you will spend time decorating your front lawns with spooky Halloween things. While you place decorative cobwebs, bats, flying witches, skeletons and tombstones all over your yard, some of your machines back at the plant floor might be getting ready for Halloween, too. Maybe they already have a white sheet covering them. Maybe they are covered by real cobwebs. On this Halloween night, when you least expect it, they will turn on, roam the plant floor, and chase after you, screaming, "BOO!"

OK, the chances of your industrial machines hunting you down are pretty slim, but if you don't maintain them and keep them up to date, they might malfunction, forcing you to shut down, and that is a scary situation in itself.

Before you find yourself in that scenario, make sure you pay attention to what your industrial equipment tells you. Don't be scared of alarms. This is how devices communicate with us. If you are scared of alarm systems going off, I recommend you follow this advice: Remain calm, follow safety procedures, and solve problems quickly and effectively.

Read my column "Scared of Alarms?," where I point you to two different white papers that can help you better understand alarms and better prepare you to deal with them when they go off. Visit www.ControlDesign.com/alarms to learn more.

Are you afraid of the dark? You should be, and not just because spooky things happen at midnight when the lights are off. For machine builders and industry professionals, having your equipment down due to power outages means money down the drain.

If you want to learn what you can do to prevent a voltage overload, how to select the right power supply, what the different types of power problems are, and how you can reduce operational expenditures while increasing productivity and efficiency, read my article "Don't Be Left in the Dark." Check in at www.ControlDesign.com/dark and start learning now.

Have you ever been to a haunted house? Those are packed with unexpected surprises jumping at you—doors flying open, things falling from the ceiling or popping up from the floor. You know what is as scary as a haunted house? An unprotected network system.

In the article "The Only Evil," Executive Editor Jim Montague says that with the emergence and adoption of Ethernet, Internet and wireless technologies, linking thousands of devices worldwide, many control and automaton engineers are scared their networks and applications will be hacked and damaged. Industry professionals continually seek software solutions or hardware modules that can help them protect their applications.

Read Montague's article at www.ControlDesign.com/evil to learn about solutions that he suggests can protect and strengthen the security of your industrial network.

Have a safe and happy Halloween, and don't let those old machines scare you. CD

CONTROLDESIGN.COM
Katherine Bonfante · managing editor, digital media · kbonfante@putman.net

Technology by **THE INNOVATORS**

Advanced Panel Solutions

- Extremely low overall costs possible through the use of long-lasting, maintenance-free products
- PC technology with long-term availability that coincides with the life cycle of the system
- Individually tailored to the ergonomics, design and operating characteristics of the machine
- Fulfills requirements specific to each industry
- Minimized hardware and engineering costs through a complete and scalable range of products

Booth 4337

Perfection in Automation

www.br-automation.com

control design
FOR MACHINE BUILDERS

In Memory of Julie Cappelletti-Lange, Vice President 1984-2012

PutmanMedia®
555 W. Pierce Rd., Suite 301
Itasca, Illinois 60143
630/467-1300
Fax: 630/467-1124

EDITORIAL TEAM

EDITOR IN CHIEF
JOSEPH FEELEY
jfeeley@putman.net

EXECUTIVE EDITOR
JIM MONTAGUE
jmontague@putman.net

MANAGING EDITOR
AARON HAND
ahand@putman.net

MANAGING EDITOR, DIGITAL MEDIA
KATHERINE BONFANTE
kbonfante@putman.net

ASSOCIATE EDITOR, DIGITAL MEDIA
SARAH CECHOWSKI
scechowski@putman.net

SENIOR TECHNICAL EDITOR
DAN HEBERT
dhebert@putman.net

EDITORIAL ASSISTANT
LORI GOLDBERG
lgoldberg@putman.net

COLUMNIST
JEREMY POLLARD
jpollard@tsuonline.com

DESIGN/PRODUCTION

SENIOR PRODUCTION MANAGER
ANETTA GAUTHIER

ASSOC. ART DIRECTOR
ANGELA LABATE

SUBSCRIPTIONS

CUSTOMER SERVICE
888/644-1803

CIRCULATION

AUDITED MAY 2012

Air & Gas Compressors	790
Engineering & Systems Integration Services	8,524
Engines & Turbines	1,543
Food Products Machinery	2,195
Industrial Fans, Blowers & Air Purification Equipment	840
Industrial Heating, Refrigeration & Air Conditioning Equipment	1,494
Industrial Process Furnaces & Ovens	1,028
Machine Tools	4,078
Materials Handling, Conveyors & Conveying Equipment	1,870
Metalworking Machinery	3,729
Mining Machinery & Equipment	671
Oil & Gas Field Machinery & Equipment	1,211
Packaging Machinery	959
Paper Industries Machinery	369
Printing Trades Machinery & Equipment	519
Pumps & Pumping Equipment	825
Rolling Mill Machinery & Equipment	193
Semiconductor Manufacturing Machinery	1,392
Textile Machinery	225
Woodworking Machinery	339
Other Industries & Special Industrial Machinery & Equipment NEC	7,226
TOTAL	**40,020**

BPA WORLDWIDE

Please Recycle This Magazine

Parts by Addition

HERE'S A QUICK note about two of the many slick things at September's IMTS 2012. The event now includes an Industrial Automation North America (IANA) conference and exhibitor component produced by Deutsche Messe, the folks who do the Hannover Fair.

In halls dominated by machining centers, I found a very different machine that doesn't cut metal to make industrial-grade parts. It builds parts layer by layer.

This is additive manufacturing. Some methods are called 3D printing. Five or six companies exhibited various types of this technology. In the Emerging Technologies Center, ExOne (www.exone.com) showed one of its machines, which in basic terms is a giant inkjet printer with a z axis. It selectively dispenses chemical binder into thin layers of powdered metal or plastics. This additive process creates parts or molds for parts directly from CAD data. Its sweet spot is simplifying and reducing the cost of complex parts, including those with quantities that make molds too costly. Lot size rendered unimportant? Consider that.

Process control is dedicated, hardwired and proprietary in these companies. Standards-based control holds too much risk to their intellectual property. So, as this industry matures, won't they need more-open systems to keep up? "All these systems came from very proprietary ideas in the back room, and not shared one bit," says Dan Maas, who does business development for ExOne. "We won't open up the PLC to customers, let alone process control. We won't risk the liability of crashing a $30,000–40,000 print head."

You see similarities with the way the semiconductor industry's wafer processing evolved from unique control systems designed by the ChEs who were in charge then, not the EEs. It worked, though yields were awful, and they eventually untangled the homegrown, one-of-a-kind stuff to more-manageable, standardized systems as production and quality demanded more.

"On our list of 1,000 things to do, controls isn't at the top," Maas told me. I understand. But if this industry grows like it looks capable of during the next five years, better controls will climb that list fast.

I also visited the cryogenic tool-cooling process for machining titanium in the MAG booth. It got a lot of buzz at IMTS 2010 with claims of faster cutting, longer tool life, and big environmental advantages.

> **"These systems came from very proprietary ideas in the back room, and not shared one bit."**

MAG had the process on a new five-axis HMC, and on a retrofitted VMC. The focus has been on the hardest materials such as titanium, nickel-based alloys, and compacted-graphite iron, although MAG maintains that the ROI should work for less-difficult materials. They can't prove it yet, but they say the economics of the environmental savings and eliminating flood cooling will stand on its own.

The process was approved by the U.S. government for roughing titanium components for the F-35 fighter, and MAG expects finished machining approvals by early 2013. Catch up on the story at www.ControlDesign.com/IMTS. CD

Joe Feeley

Joe Feeley · editor in chief · jfeeley@putman.net

Connect to any control system, without limits.

There are many controls out there, and you want to talk to any of them for any given project. ABB understand the importance of connectivity and gives you the choice of which factory control systems you want to connect to, using the language it understands. With communication modules embedded into the drive, or added as an adapter, our product gives you the power to choose which system you connect to. Find more information at http://drivesanswers.com/31

ABB
Low Voltage Drives
New Berlin, WI
Tel: 800-752-0696
Web: www.abb.us/drives

Power and productivity
for a better world™

More PLC Memories

Regarding Jeremy Pollard's column, "PLC Genesis" (June 2012, www.ControlDesign.com/genesis), I have to weigh in with my (perhaps faulty) recollections of the programmable controller name transition from PC to PLC. In 1973 and '74, I worked for Texas Instruments designing anti-lock braking (ABS) controls. This, of course, is an automotive product, and the first programmable controllers were designed for the automotive industry, so TI's PC designers were in the same department. In 1974, they clearly were called PC for "programmable controller."

My next contact with programmable controllers was in 1979 at a publication printing company where a Modicon 384 was applied to control a rotogravure printing press. Programmable controllers were still called PCs at that time. The PC abbreviation also meant "printed circuit," but context usually sufficed to keep those two straight.

As we all realize, the IBM-PC brand name added confusion. Even Xerox tried using PC for "personal copier." One trade journal changed its name from *PC Design* to *Printed Circuit Design,* probably because people were disappointed to find that the magazine was not describing how to build personal computers.

I first saw "PLC" used by Allen-Bradley (I believe one of its models was called PLC-01) to distinguish its product from distributed control systems (DCS), which were primarily concentrating on PID loops, i.e., analog control. The switch from PC to PLC seemed to happen naturally and quickly, with A-B not objecting to usurping its trade name and all of us users and instructors happy to be rid of the abbreviation confusion. Today it is PC (politically correct) to call them PLCs.

MARVIN T. ANDERL, happily retired

Get Some IT Help

As always, Jeremy Pollard hit the nail on the head with his latest column ("Wolf at the Cyber Door?" September 2012, www.ControlDesign.com/wolf). I am very concerned about many of my customers' security (or lack of it) for their control systems.

A majority of my customers are small water and sewer utilities. I have put in the SCADA systems and set up security the best I know how. However, what I find is that all their PCs are on a simple peer-to-peer networks, running out-of-date (non-updating) antivirus, and no firewalls. All drives on the network are shared. I can see file folders labeled Payroll, Budget, etc., and have full access to them. While setting up a SCADA system at one site, for three days there were two job applications lying out in full view on the desk with all personal data visible!

When I insist on user passwords, I get "1234" for the operators (no setpoint control, view only) and similar four-digit passwords for supervisors with full access.

I don't believe we have to fear terrorist organizations as much as the kid in the apartment building next door!

In all honesty, I feel they need an IT person to configure security. I am not skilled at that and cannot keep up to date on

those threats and my own areas of responsibility, too. Most days, I don't feel I have enough competence for my own work!

Keep up the great work.

JIM MEMMER, CET,
JH Memmer Technical Services,
www.jhmemmer.com CD

GIVE US A PIECE OF YOUR MIND

WE WELCOME your comments, suggestions, criticism and praise. We're particularly fond of the praise, but we really do value the criticism.

EMAIL US at ControlDesign@putman.net or post a comment in our forum at www.ControlDesign.com/mbf.

Reliable and Flexible Panel Designs

Panduit provides high quality product systems that connect, manage, and protect today's industrial systems throughout the physical infrastructure – from on machine control panels to facility electrical panels. Key product features include:

- **Space Optimization:** Increase space savings and design flexibility in control panel layouts with innovative wiring duct
- **High Quality Connections:** Improve system reliability with ferrules and tooling that provide superior performance
- **Safe and Secure Access:** Maintain and monitor industrial networks using data access ports

Comprehensive Systems To Meet Your Needs

- *Wiring Duct*
- *Ferrules, Disconnects, and Terminals*
- *Outlets*
- *Installation Tools*
- *Cable Ties and Wiring Accessories*
- *Power and Grounding Connectors*
- *Abrasion Protection*
- *Labeling and Identification*
- *Safety and Facility Signage*
- *Copper Cabling Systems*

PANDUIT®

building a smarter, unified business foundation

Connect. Manage. Automate.

Visit **www.panduit.com/panel-cd** today for free control panel reference documents that can help to lower your panel costs.

Practical Panel Meter Choices

DIGITAL PANEL METERS provide an indication of machine and process conditions, but also contain a host of added functions. Of course, these added functions aren't free, adding not only cost but also varying degrees of complexity. That's why it sometimes makes sense to use an analog panel meter.

"Analog panel meters are a low-cost solution to provide a visual cue if the machine or process is operating as expected within a given range," says Greg Hendry, product manager for the meter and instruments division at Yokogawa Corp. of America (www.yokogawa-usa.com). "Analog meters don't require external power, as they are powered from the input signal. A typical analog panel meter has an accuracy of ±2%. Common input signals are ac or dc amps or volts, with custom scales possible." Application examples, Hendry adds, would be to use the input frequency of an ac input signal to indicate ac frequency, or as a time meter.

"Use a digital panel meter when a more precise reading is required as they have an accuracy of ±0.05% or less," Hendry continues. "Digital panel meters also can incorporate control, output and communication functions—giving them added features as compared to analog panel meters, but at a higher price point."

It seems the list of digital panel meter features is limited only by the imagination and the needs of machine, robot and process skid builders. In addition to real-time control, other digital meter features include signal conversion, web server capability, and wireless communication with sensor networks.

Moore Industries (www.miinet.com) makes a meter that can be used for alarming purposes, as well as signal conversion and retransmission. "Our process monitor and indicator accepts a thermocouple or an RTD signal input," notes Matt Moren, director of sales support at Moore. "Two fully independent alarms may be specified. Each may be individually configured for high and low set points and a variety of latching sequences. Additional models are available with an analog output signal (proportional to input) for retransmission, and with RS-485 communications."

Moore Industries' meter, like many panel meters, is programmed with front panel keys. This simplifies long-term maintenance because there's no programming software to keep track of, and no need to lug around a PC. This simplicity is a virtue of panel meters, particularly for basic machines with limited analog monitoring and control requirements.

Though simple to program and maintain, panel meters can control sophisticated operations such as weighing and scaling. "Our weight indicator/controller panel meters have a one-touch (no weights, no wait) calibration feature and can be used with a self-diagnostic load cell," says Rodger Jeffery, director of marketing and business development at Hardy Process Solutions (www.hardysolutions.com).

An embedded web server allows remote connection to the meter from anywhere in the world via a web browser. "To help reduce the time and cost of integrating our meters into machine or skid control systems, we provide pre-tested PLC code," Jeffery adds. "In terms of control, the meter's pre-act weight can be adjusted in real time based on current feed conditions, simplifying control and helping to minimize over feeds."

In addition to real-time control, digital meter features include signal conversion, web server capability, and wireless communication.

Omega Engineering (www.omega.com) has a line of controllers that can be configured for PID or on/off control. Output options include solid-state relays, SPDT relays, pulse, and isolated programmable analog voltage/current.

Transducer inputs to the meter can be hard-wired or wireless. "Our point-to-point extended range (300 ft) wireless transmitters and our high-powered NEMA-rated extended range (1,000 m) transmitters both support a wide range of Omega transducers for extended flexibility in setting up your system solution," explains Daniel Sparks, Omega product manager. "Our 1/8 DIN panel meter-controller can monitor up to eight wireless sensors. The compact instrument connects directly to an Ethernet network, or can be connected to the USB port of a computer with a USB Ethernet adapter." CD

Dan Hebert, PE · senior technical editor · dhebert@putman.net

we did

WHAT ~~COULD YOU DO~~ WITH MORE CONTROL

INTRODUCING THE NEW 22.

The most innovative line of American-made 22mm pilot devices.

Leading the industry with the shortest depth 22mm Pilot Devices made in the U.S.A., c3controls' new compact line saves you valuable space in your control panel and significantly reduces installation time and overhead costs. Our design allows for quick assembly and disassembly of the products—no tools required!

We have engineered a higher standard of safety requirements into our Push-Twist-Release, which conforms to the EN418 directive. With simpler installation and maximum safety features, c3controls' new line of Pilot Devices exceeds the demands of our customers and the industry.

Imagine the possibilities. At c3controls—it's what we do every day.
Go now to www.c3controls.com/new22 and see the difference for yourself.

WE DIDN'T INVENT CONTROL, WE'RE PERFECTING IT.

c3controls®

LIFETIME WARRANTY · GUARANTEED SAME-DAY SHIPPING · FACTORY DIRECT PRICING

Making Good Neighbors

Aaron Hand · managing editor · ahand@putman.net

ANYONE VISITING Disney World's Magic Kingdom in August is likely to appreciate the sweet relief of the cool, slow boat ride of It's a Small World—followed by the frustration of realizing that the sugary, sticky song will never, ever, leave your head. Yes, it can be a surprisingly small world at times, and as I look ahead to next year's coverage of our Global Machine topic, my mind is focused on the ways that machine builders can not only survive themselves, but help their customers compete globally.

And yet, I'm equally struck by the steps manufacturers take to operate on a local level as well, building good relationships with local suppliers and the communities that they live and work in.

In September, Lenze Americas celebrated the official opening of a new production facility in Glendale Heights, Ill. That's just a stone's throw from our office, so Joe Feeley and I checked in on them to take a look at the new digs.

In deciding where to locate their new 100,000 ft^2 assembly and logistics facility, Lenze got some university folks to run some models. They figured out that the center of Lenze's universe was about 100 miles south of here, so they ultimately settled on this small western suburb of Chicago, where there's no shortage of industrial activity.

While showing us around their production facilities, Lenze officials repeatedly commented on the great relationship they've formed with KMI Systems, a turnkey system manufacturer about an hour up the road in Crystal Lake, Ill. KMI makes the conveyor systems that carry Lenze motors and gearboxes through paint and bake processes.

Lenze necessarily gets some of its supplies, including home-ground gears, from its parent company in Germany, and those supplies take some five weeks to reach the Chicagoland facility. But the facility is also trying to localize sourcing as much as possible, according to Gene Wood, director of operations for Lenze Americas, to help reduce leadtimes and transportation costs, for example. KMI is just one example of those great neighbors you hear about in old movies and State Farm commercials. "There's an abundance of people in the machine business here," Wood notes.

With our publishing offices located in Northwest Chicagoland, we're surrounded by some pretty great neighbors as well. I got to meet several of them at the latest IMTS show—DMG/Mori Seiki in Hoffman Estates, Ill.; Fanuc FA America, also in Hoffman Estates; and Mitsubishi Electric Automation in Vernon Hills, Ill., just to name a few—and we talked about getting together for future play dates.

When I covered semiconductor manufacturing from Chicagoland, I never got that sense of community that my Silicon Valley-based co-editor did. But covering machine automation from Chicagoland—now that's a different story. And it actually surprises me that in this day and age of global coverage, there's something to be said for the closeness you feel to your neighbors.

I've got a similar feeling of camaraderie with my neighbors where I live in Northwest Indiana (i.e. Southeast Chicagoland). I coach their kids in soccer, we carpool to early-morning choir practices, and they tolerate the collapse of their lovely brick mailbox when my 300 lb trampoline sets sail in a wind storm (well, the insurance money probably helped).

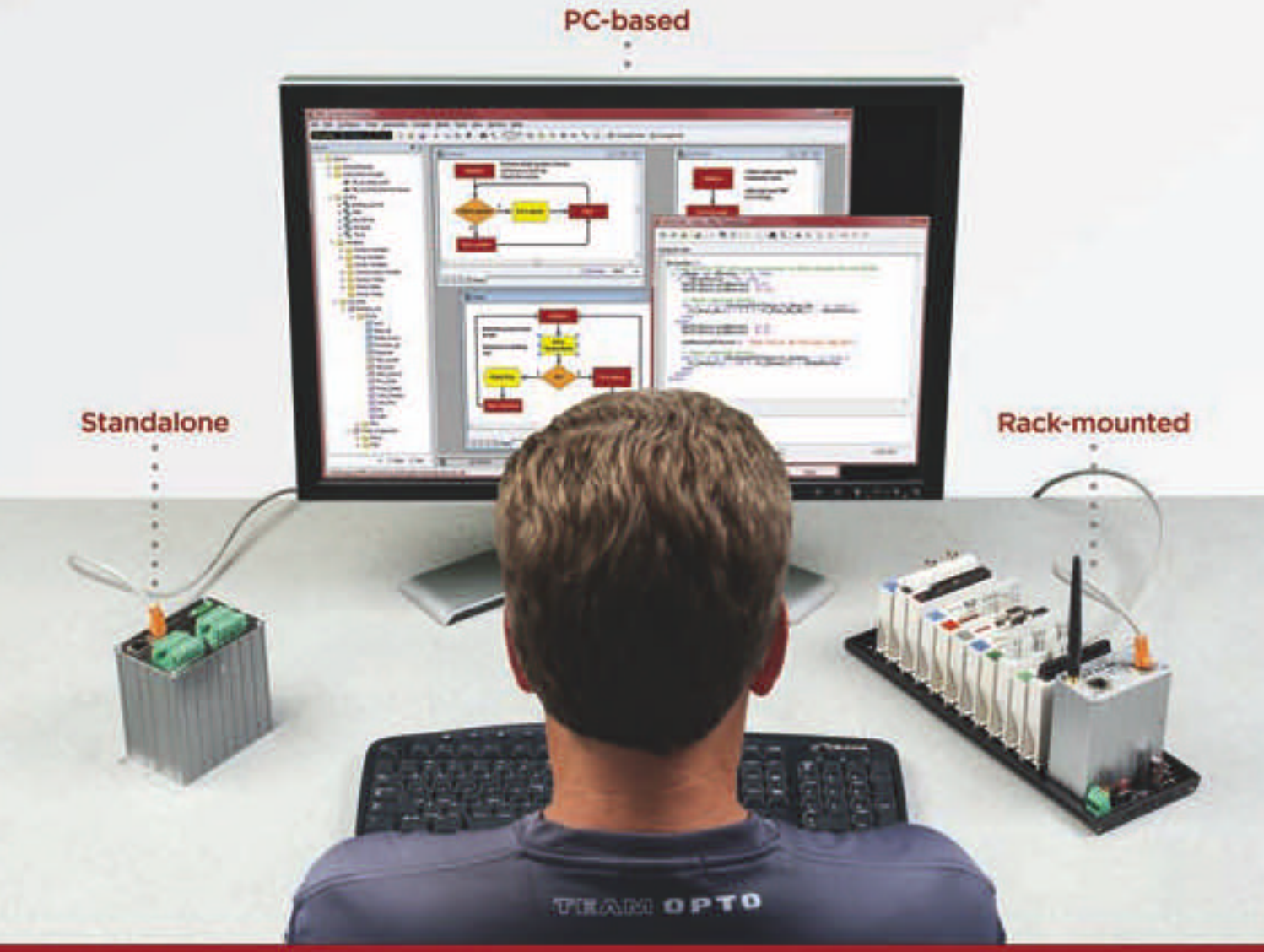
With offices in Chicagoland, we're surrounded by great machine and automation neighbors. We should set up a play date.

So I wasn't too surprised last night when a young neighbor from across the street brought us over a big six-pack of white cheddar shells that her mom had brought home from work. What I was surprised about was to hear that this mother works for the company that makes the machines that shrink-wrap the boxes of noodles. Her company, Arpac, is located in Schiller Park, Ill., just east of our offices here, so we share a very similar commute, skirting the boundaries of the city. I see more carpooling in our future, and I think we'll be having a few more conversations about the world of food packaging machinery.

And what's one of the first things she tells me? How difficult it is to hire engineers and technicians. How many times have we heard that? And what was the No. 1 difficulty Lenze faced when setting up its new shop? Finding the skilled workforce. Wood marveled at the fact that about half the job candidates didn't even show up for their first interviews.

Meanwhile, one thing a company can do is be that good neighbor, building a community where engineers and operators want to work. It's a small world, after all. CD

Choices.



You choose where to do control.

With SoftPAC™, you can take advantage of a PC's extensive memory, file space, and speed for your control application. Or run your control strategy on industrially hardened SNAP PACs. Software-based PAC or hardware PACs? The choice is yours.

Visit http://softpac.opto22.com.
Or scan this QR code with your smart phone to learn more.

MADE IN THE USA

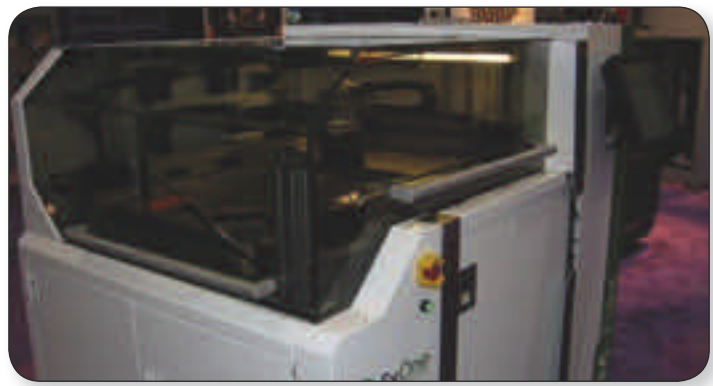
Made and supported in the U.S.A. Call us toll-free at 800-321-6786.

OPTO 22
Automation made simple.

It All Adds Up

ExOne Machines Jet Binders onto Sand or Metal Powders to Make Parts

FOR VISITORS OF last month's International Machine Technology Show (IMTS) who weren't already familiar with additive manufacturing, they were able to get a taste of it in the IMTS Emerging Technology Center, at the main entrance to the North hall. There, for example, they could see the latest 3D printer from ExOne (Figure 1), which builds intricate parts and castings through successive powdery layers of metal, sand, glass, ceramics or other materials.



3D DISPLAY

Figure 1: ExOne displays its latest 3D printer at the IMTS Emerging Technology Center. The M-Flex 3D Printing System builds metal parts one layer at a time by inkjetting binders onto thin layers of metal powder.

In a show crowded with enormous booths running oversized milling and grinding machines, the aisles featuring additive manufacturing could have seemed a little quiet and out of place. But they just might be the new face of part manufacturing, able to produce quantities of one as easily as quantities of 1,000; and able to make complex and ornate metal designs without having to accommodate the constraints of traditional subtractive processes (Figure 2).

ExOne (www.exone.com) is based in Irwin, Pa., some 20 miles outside of Pittsburgh. Founded about seven years ago as a spin-off of surface finishing provider Extrude Hone, ExOne makes its own automated machines and also provides contract services. At IMTS, the company showcased its newest machine, the M-Flex 3D Printing System, which ExOne says offers more than seven times the volume output of additive manufacturing machines currently in use.

The M-Flex is designed mainly for manufacturing metal parts for use in such industries as mining, automotive and energy. It makes some of the same parts being made by heavy industrial machines that were on display elsewhere on the IMTS show floor, but in an entirely different way. Rather than turn, mill and grind a part from metal, ExOne's machines start with metal powders (typically stainless steel, but also tungsten) and build the part from the bottom up (or top down), layer by layer.

The process starts with a CAD rendering of the finished product, which is sliced into thin layers (0.1–0.15 mm each) and sent to the specialized printer. The machine creates the product by putting down a layer of finely powdered metal in a build box, on top of which a print head selectively deposits a liquid binder according to the design for that layer. This process is repeated hundreds or thousands of times until all layers are completed. The build box now contains one or more complete parts surrounded by loose powder that has to be carefully blown away before the part goes into a furnace to burn out the binder and sinter the metal. The hardened part, at this point about 60% dense, is then infiltrated with bronze to bring it to 100% density and make it ready for use.

Making molds and cores for casting relies on a similar printing process that uses foundry-grade sand put down in layers 0.2–0.5 mm thick. In this case, after the loose sand is removed from the mold or core, it is ready to be sent to a foundry for the casting process.

From an automation standpoint, there are factors in this process that make it similar to some more commonly known machine processes, such as 2D printing. The machine uses inkjet print heads, for example, and must be concerned with maintaining fine resolutions to keep manufacturing precise. "We're printing voxels instead of pixels, but we're still dealing with resolutions like in printing," explains Bob Wood, ExOne's

Ferraz Shawmut is now

MERSEN

We've shortened our name. And increased your expertise in ensuring the safety and integrity of power electronics systems.

Power electronic protection covers a lot of ground, from air- and liquid-cooled heat sinks, to semiconductor fuses and fuse holders, to switches, wire management, and surge protection. Mersen helps you cover all of it. Now we have more products, solutions, and support to help you increase uptime and energy efficiency while protecting equipment — and the people who work with it. Ready for more? It's waiting for you at **fsisnowmersen.com/us/CD_PE**

ep-us.mersen.com

Mersen
Newburyport, MA
T: 978.462.6662
info.nby@mersen.com

general manager. "We're dropping binder on demand, so things like time of flight become important. We have to have very fine-tuned actuators for the x and y print planes. And data transfer is a big deal for us."

Wood also notes the similarities with waterjet machining. "They're taking away material instead of adding it, but the control is very similar," he says.

Some key differences from 2D printing come from the materials that additive manufacturing works with. "You have to consider the ballistic impact of the binder; how it affects the spherical powder," Wood says. He also notes the increased burden of keeping the inkjet nozzles in working order, considering that they are essentially shooting glue through those print heads.

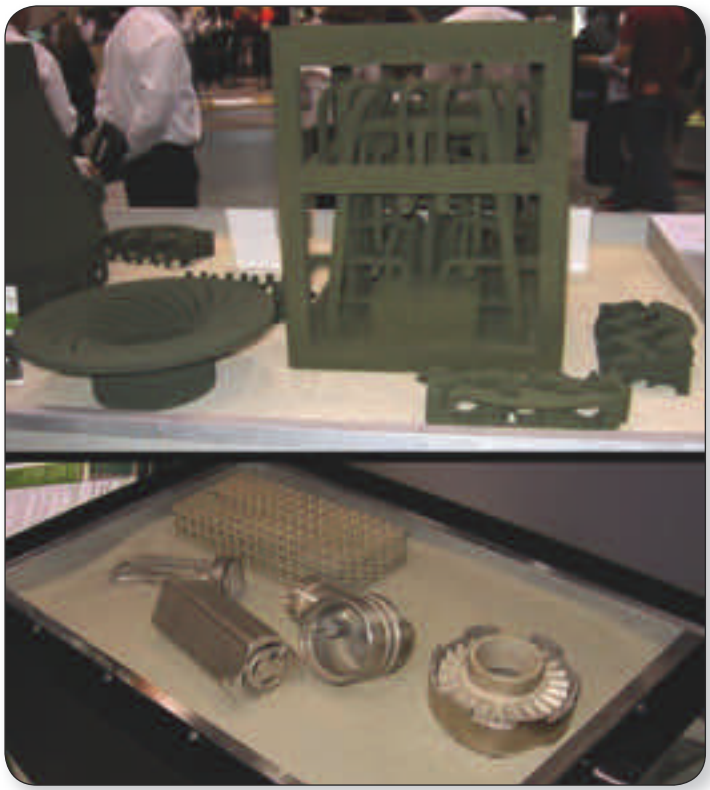
On the one hand, ExOne's additive manufacturing processes are highly controlled in that they rely on sophisticated mathematical models to render designs and configure the most efficient way to nest parts in the build box. All software is developed in-house for the metal machines, Wood says, and ExOne has a relationship with a university to create the software for the sand machines. The machines could run for days without intervention, Wood notes. As mentioned, precise control of print head location is necessary, and also rolling out the fine powder layers requires extreme precision to make those layers flat and uniform.

On the other hand, there is much of the process that could still be automated. "Additive manufacturing is really in its infancy on automation, especially on the material handling side," Wood says. "There's still a lot of potential for controls."

For instance, one build process could fill a build box with literally thousands of small cores. Each of those cores—which at this point are so fragile as to be easily crushed—must be removed by hand and the excess material blown off by a hand tool. They are transferred by hand from box to box for sintering and infusion. "We could really automate the removal of the cores," Wood says, noting the time that could be saved in the process with automation.

As it is, ExOne continually looks for ways to speed up the process. Considering the hundreds or thousands of layers used to build any given piece, saving just a second off of each layer makes considerable difference. "There are about 250 layers in an inch," Wood notes. "So we look at things like how to save 2 s in a layer." The latest M-Flex machine achieves build speeds of 30 s per layer, compared with previous build speeds of about a minute and a half per layer.

"We've made tremendous strides in 3D printing in the last decade, and what our machines can do today is simply remarkable," said Dave Burns, president of ExOne. "We are printing engine castings for helicopters and replacing broken pumps in oil fields in days—not months." CD



SIMPLIFIED INTRICACIES

Figure 2: Additive manufacturing, or 3D printing, produces complex shapes with one process, creating sand molds for casting (top), for example, or finished metal parts (bottom).

Terminal/PLC Combo to Rise in Popularity

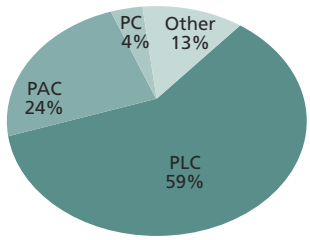
IMS RESEARCH (www.ims-research.com) expects global sales of operator terminals with embedded PLC hardware to rise from $99 million in 2011 to about $148 million in 2016, reflecting a compound annual growth rate (CAGR) of about 9% over the forecast period. Such lean automation solutions provide space and cost savings over traditional configurations.

"There are two principle advantages for OEMs using operator terminals with embedded PLC hardware: price and footprint," said Mark Watson, senior research analyst for IMS Research. "Every component has an associated cost and space requirement. By combining two systems into one, both factors are reduced. This enables further savings as the combined unit doesn't require extra wiring to communicate between subsystems, and maintenance departments only need to support one product type."

The largest vertical sectors for operator terminals with embedded PLCs in 2011 were estimated to be food, beverage and tobacco machinery; machine tools; and packaging machinery. Collectively, these sectors accounted for about 35% of sales revenue. The largest unit shipment growth is also forecast to come from the food and beverage machine sector, with annual shipments increasing by more than 5,000 between 2011 and 2016.

The advantage of using combined solutions is most significant for small machines, where price and space are at a premium, Watson noted. "Manufacturers of larger machines typically have the space and the budget to adopt a traditional solution of separate operator terminal and PLC units. This solution also provides flexibility in terms of the component supplier of each unit, and enables OEMs to cherry pick the most suitable two components for specific applications."

Though the combined operator terminal type is expected to see strong revenue growth to 2016, average selling prices are projected to decrease by about 3% per year. Leading suppliers such as Pro-face, Unitronics and Horner APG will therefore have to work hard to maintain revenue growth as price pressure drives down selling prices over the next few years, Watson added.



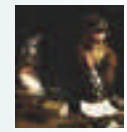
THE PLCs HAVE IT

With automation and control functions split pretty evenly between motion, analog, sequential and discrete, well over half of the respondents to our latest Market Intelligence Report said they rely on PLCs as their primary controller platform for machine automation.

FLASHBACK 1997-2012

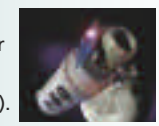
15TH ANNIVERSARY

- **Oct. 15, 1997:** British Royal Air Force pilot Andy Green broke the land-speed record by driving a jet-powered car faster than the speed of sound.
- **Oct. 29, 1998:** The oldest known copy of Archimedes' work sold for $2 million at a New York auction.



- **Oct. 1, 1999:** The People's Republic of China celebrated the 50th anniversary of its founding.
- **October 2000:** The United Nations estimated that there were 742,500 industrial robots in use worldwide. More than half of those were being used in Japan.
- **Oct. 16, 2000:** Chevron announced that it would buy Texaco for $35 billion. The combined company became the fourth largest oil company in the world.
- **Oct. 24, 2003:** In London, the last commercial supersonic Concorde flight landed.

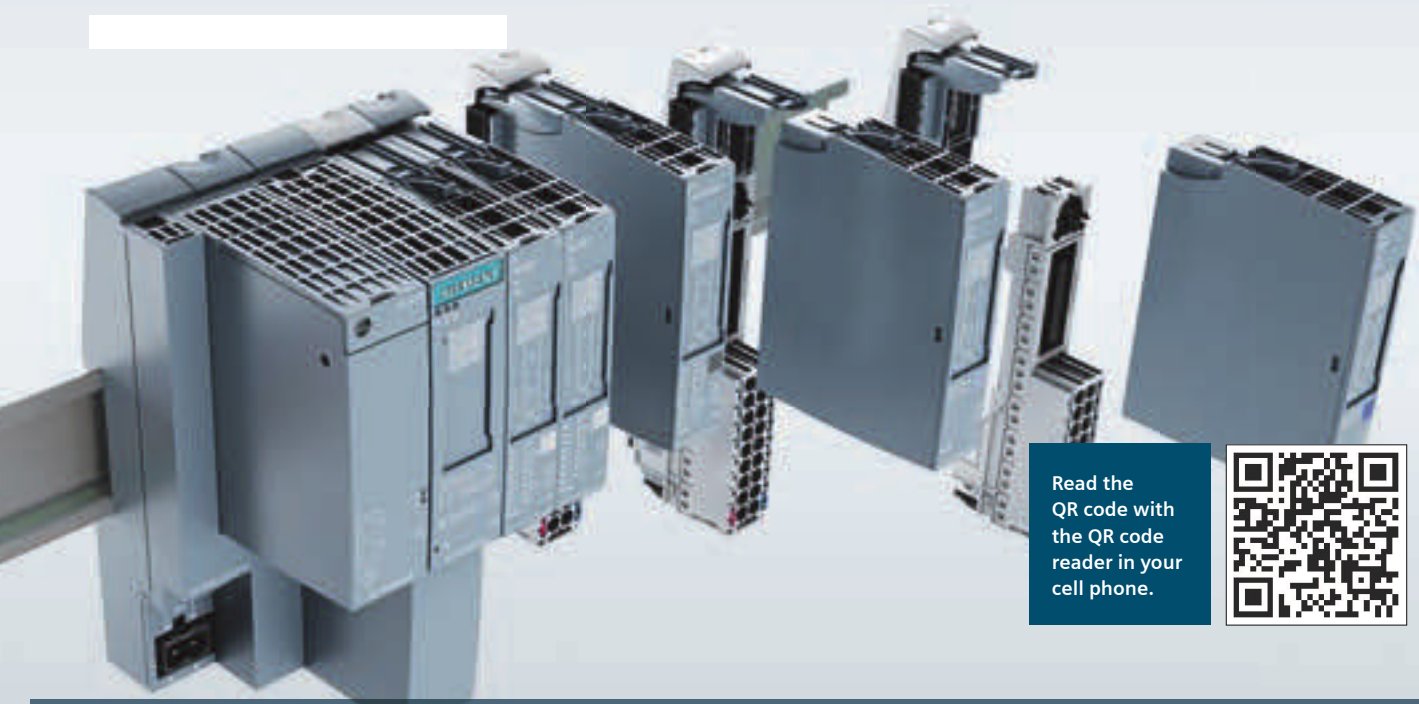
- **Oct. 20, 2004:** The United Nations reported that Japan was using 320 robots of all sorts per 10,000 employees, and Germany was using 148 industrial robots per 10,000 employees. In the car industry, there was one robot per 10 workers in Japan, Italy and Germany.
- **Oct. 9, 2009:** NASA launched the Lunar Crater Observation and Sensing Satellite (LCROSS).



- **Oct. 22, 2010:**

The International Space Station set the record (3,641 days) for the longest continuous human occupation of space.

SIEMENS



Read the QR code with the QR code reader in your cell phone.

SIMATIC ET 200SP

Simple to use. Smaller in size. Stronger in performance.

A new generation of distributed periphery
Increase the efficiency of processes and the productivity of a plant – the distributed periphery SIMATIC ET 200SP supports plant engineers and operators in meeting these challenges. The sophisticated concept of the system offers significant benefits for you.

The easy use of the SIMATIC ET 200SP is apparent in the clear arrangement and easy installation of the modules, the clear labeling system, the tool-free wiring, and the efficient engineering.

The compact design of SIMATIC ET 200SP ensures maximum economy in the switching cabinet: 64 modules with 64x16 signals can be accommodated on one meter. The observance of the standardized bending radii is ensured as well.

The strong performance of the system results from the communication via PROFINET, the leading Ethernet standard of automation. The back panel bus of SIMATIC ET 200SP is synchronous and ensures highest precision and fastest data transfer. You profit from maximum energy efficiency thanks to the integration of PROFIenergy.

Discover all highlights and details of the SIMATIC ET 200SP in 3D:

www.usa.siemens.com/et200sp

Equipment Leasing Business Up 21%

ECONOMIC ACTIVITY for the $628 billion equipment finance sector showed that new business volume for August was $6.9 billion, up 21% from the same period in 2011, according to the Equipment Leasing and Finance Assn.'s (ELFA, www.elfaonline.org) Monthly Leasing and Finance Index. August volume was up 5% from July, and year-to-date cumulative new business volume increased 16%.

"The pace of new equipment financing continued throughout the summer months as the housing sector, for one, showed signs of a rebound," said William Sutton, ELFA's president and CEO. "However, businesses, both large and small, continue to build up cash reserves, indicating lingering apprehension over increasing energy prices, instability in the Arab world, and a still fragile Eurozone economy."

Thomas Depping, CEO of Ascentium Capital, said the credit quality of applications at his company remains uncharacteristically strong, with delinquencies at historic lows. "Although we have hedged ourselves against another possible global economic slowdown, we continue to expand our sales force as we have a generally optimistic view of our future," he said. "One thing I have learned over the past 30 years in the industry is that being over-capitalized and having substantial excess liquidity is never a bad thing."

Despite concerns over whether companies will expand their businesses in the face of economic and political uncertainty, September's confidence index actually shows increased optimism, according to a separate report from the Equipment Leasing and Finance Foundation (www.leasefoundation.org). September's Monthly Confidence Index was 53.0, up from August's 50.2.

"The industry is performing well and new businesses are entering the segment to join the positive experience our asset class enjoys," said survey respondent Anthony Cracchiolo, president and CEO, vendor services, U.S. Bank Equipment Finance. "However, the growth of our industry is tightly aligned with the overall U.S. economy, and our industry's future will be determined by the broader actions of the U.S. economy."

MERGERS, ACQUISITIONS & ALLIANCES

The Drives & Motion Division of **Yaskawa America** (www.yaskawa.com) acquired **Wermac Electric** (www.wermac.com). Wermac supplies software, packaging solutions and on-site services, and has partnered with Yaskawa for 25 years to apply variable-speed drives and electrical controls to the oil and gas industry.

Swagelok (www.swagelok.com) acquired the assets of **Innovative Pressure Technologies** (IPT, www.inpressure.com) to broaden its offerings for fluid system technology customers. IPT makes valves, fittings and fluid control devices.

Industrial distributor **Kaman Industrial Technologies** (KIT, www.kaman.com) completed its acquisition of **Zeller** (www.zellercorp.com), expanding KIT's capabilities in electrical, automation and engineered systems, including motion control, machine vision, electrical controls and power distribution.

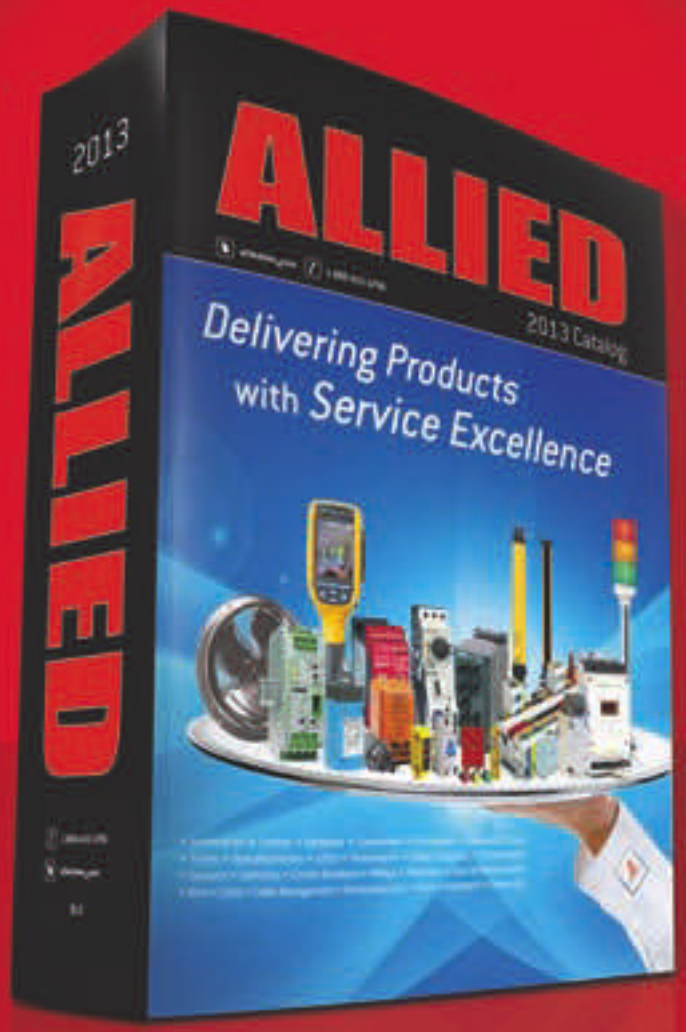
The **University of Alberta** (www.ualberta.ca) joined the **ASM Consortium** (www.asmconsortium.net), which is geared toward reducing and mitigating abnormal situations in process industries. Sirish Shah and Tongwen Chen, both professors of engineering, will represent the university in the consortium.

NOTEWORTHY

InduSoft (www.indusoft.com) launched an educational version of its Web Studio HMI/SCADA software for students and researchers at higher education institutions. The goal of the program is to provide students a complete SCADA/HMI package that enables them to develop real-world applications, without limits on development time.

Eaton (www.eaton.com) introduced an online tool, Circuit Breaker Authentication (CBA, www.eaton.com/counterfeit), to enable customers to identify counterfeit circuit breakers in an attempt to thwart potential danger and allow for authorities to be informed.

You Have Big Ideas
We Have a Big Catalog



2013 Allied Catalog

Over 110,000 products | **Over 10,000** new products | **Over 300** world-class suppliers

New suppliers include **Siemens Corporation** and **FLIR Commercial Systems**

alliedelec.com

ALLIED ELECTRONICS

1.800.433.5700

South African Automation to See Growth

SOUTH AFRICA'S automation market is seeing activity in more than just mining these days, with the inflow of foreign direct investment prompting growth in several sectors, according to the ARC Advisory Group (www.arc-web.com). After a flat 2011, the local automation market is back on the growth track, and ARC predicts that market volume will exceed $1 billion by 2016.

A significant amount of the investments are coming from China, analysts said. Manufacturing is picking up, and the food and beverage and automotive industries are exporting more. South Africa is benefiting from developments in neighboring countries such as Botswana, Namibia and Mozambique, but also exports its products to manufacturing industries worldwide.

South Africa is still highly affected by racial inequalities, however, and ARC sees the social tension, poverty and diminished consumer spending as an inhibitor to industry growth. Also, the lack of engineers and skilled workers is a threat to growth, but local and global companies in South Africa have established a number of strategies to overcome this problem, the report said.

The largest automation market in South Africa is mining, but exports of chemicals, metal products, machinery, transportation equipment, and manufactured goods have also increased in recent years.

ARC advises companies to evaluate investments in South Africa carefully, but the group is convinced that there is great potential. ARC recommends settling in the Johannesburg/Pretoria region, and focusing on easy-to-use automation with plenty of services.

Fieldbus Foundation Registers Isolated Device Couplers

THE FIELDBUS FOUNDATION (www.fieldbus.org) announced registration of the first isolated device couplers based on its Foundation H1 (31.25 kbps) device coupler test specification. Devices from MTL Instruments (www.mtl-inst.com) and R. Stahl (www.rstahl.com) successfully completed the foundation's rigorous registration process.

Isolated device couplers are installed where the fieldbus trunk (i.e., home run cable) is connected to the various device spurs. They are designed to allow automation end users to connect more devices per coupler while permitting live segment work in hazardous plant areas. These couplers provide isolated, conditioned power to multiple fieldbus devices and protect against short circuits caused by excess current in a spur.

MTL's 9370-FB Series fieldbus barrier provides a range of complete integrated enclosure systems, instead of standalone barrier modules. All internal components are live pluggable, meaning that field maintenance can be carried out quickly and safely. The series includes six- and 12-spur versions in stainless steel or GRP enclosures, as well as a redundant option enabling improved system availability in critical fieldbus networks.

R. Stahl's Series 9411/21 and 9411/24 isolated device couplers are suitable for use in Zone 1, Zone 2 and U.S. Div. 2. The series also includes a unique power management feature: during the startup of a fieldbus segment, the spurs energize one after the other. This reduces the inrush current on a segment by up to 50%, requiring less spare energy and making longer segment lengths possible.

The device coupler test specs were updated recently to improve reliability and availability of fieldbus control system installations (www.ControlDesign.com/devicecoupler). The enhancements should give end users more confidence that registered fieldbus equipment can be employed in a control system architecture suited to industrial environments, said Stephen Mitschke, director of fieldbus products for the Fieldbus Foundation. CD

[MOTOR TRUTH #10]

Are you frequently wasted at work?

Well, forget HR. Go straight to PT Pilot® and stop wasting your valuable time fumbling through catalogs, price books, and emails to specify a gear unit or gearmotor.

PT Pilot quickly provides a quote, parts lists, 3D CAD drawing, and all motor and gear options. The truth is that there are more ways to save energy than using a premium efficient motor.

New for 2012! PT Pilot is now compatible with smartphones and tablets. So, you can literally obtain a quote at your fingertips anytime, anywhere.

Visit **www.ptpilot.com/truth10**

SEW EURODRIVE

ptpilot.com/truth10
864-439-7537

Force Fits

Jeremy Pollard, CET · jpollard@tsuonline.com

MY LAST COLUMN on security ("Wolf at the Cyber Door?" September 2012, www.ControlDesign.com/wolf) touched a nerve.

You might remember that a water plant SCADA system apparently was hacked, and a pump failed. These two unrelated events were forcibly related. One was because of the other. This was shown to be untrue, but the psychological effects of such behavior linger in the depths of us control guys.

I had some very concerned responses to my last column, and those people should be concerned. Regardless of the size of the installation or the process, the lack of security can be costly.

One reader was adamant that having control systems available on the Internet is a disaster waiting to happen. While certain pieces of information are needed to find a SCADA server, a denial of service (DoS) attack can happen at any time by using common data structures such as Hash Table and/or Hash Map and storing POST data. Should a DoS attack happen, the operators would be unable to perform actions such as responding to alarms.

The code to perform this DoS attack was published Dec. 27, 2011, and can be active on any web platform. Scary, eh?

Another example involves a hacker trolling for certain data packets. The company that was targeted makes automotive parts. The IT guy had set up the company's Internet service with AT&T and, of course, the router tables reflected the local setup, along with a static external IP, which was required for remote monitoring and configuration, as well as remote site access into the system.

The hacker(s) "learned" the IP address of the router, and tried to break through the user and password combinations. The IT guy was alerted and, after a few hours, determined what was happening. He changed the IP address of the router with AT&T, and within 10 minutes, the hacker was at it again. How did he get the new static IP so quickly? Still a mystery, but he altered the rules on the router to simply reject all traffic except for specific MAC addresses and associated IP range.

If the password rules had been lax, much damage could have resulted. Another reader lamented that when he asks for a password for the operators, he gets "1234." That's just asking for trouble.

I write in Visual Basic (VB) for various reasons. In that community, there are many developers, and I found a complete VB project for a network client/server application that facilitated file transfer from one machine (client) to another (server).

How many developers use scripts and ActiveX-type controls in their applications that no one knows about? I suspect many.

Not surprisingly, malware has become very smart. Polymorphic malware is auto-morphing, which means it changes on its own. So normal detection might work once, but not a second time because of the way these viruses are detected. Should a network connection such as a remote connection into the firewall be compromised, software can be loaded onto the target computer, and can go many places from there if allowed.

Another reader sent me a link to an article about how IT needs to help secure industrial control systems. For a municipal SCADA upgrade I'm involved with, I asked who in the IT department looks after their servers and client machines. They told me it was their system integrator. Huh? I can tell you they use pcAnywhere for remote access, and the SI uses the same password for all projects. Yikes!

> **They use pcAnywhere for remote access, and the SI uses the same password for all projects. Yikes!**

No IT involvement, so I can tell you that they are not that secure, except that the Access Control List is kept by a wireless company. They are protected, but if it was a typical LAN/WAN setup, not so much.

How can we help ourselves? Some of the more simple things would be a password process, involve IT for security and access, and if necessary have a control network firewall that is separate from the company network.

In the end, ask questions of your integrator and/or your own developers. Trust with verification is paramount, and disable all USB and CD activity. A thin-client approach might be able to thwart local sabotage, since many actions are initiated from inside the firewall. CD

JEREMY POLLARD has been writing about technology and software issues for many years. Publisher of The Software User Online, he has been involved in control system programming and training for more than 25 years.

FAST MOVERS

Ethernet's Many Variants Are Just the Ticket for High-Speed Motion Applications. Get on Board With the One That Works Best for You

by Jim Montague, executive editor

All aboard! You might want to catch this train. Ethernet has rolled over the world, and now it's arriving at the last few pockets of resistance, or at least appearing on the horizon.

It's no longer a question of whether Ethernet can handle increasingly higher-speed motion; it's just a just question of when and in what applications. But even though you can travel blazingly fast via some Ethernet-based networks, your data packets also have to stay on the rails and stop at the right stations to get where they're going. In machines, trains and on the plant floor, speed is nothing without accuracy. Ease of use helps a lot, too.

HISTORICALLY, THERE WERE TWO MAIN SCHOOLS OF THOUGHT ABOUT MANIPULATING ETHERNET TO SERVE IN HIGHER-SPEED MOTION: TIME SLICING AND TIME STAMPING.

"We've been using EtherNet/IP for motion in our palletizers for six or eight years," says Kevin Davis, electrical design manager at Production Automation (PAI, www.palletizers.com) in Montgomery, Ala. "Today, even in our high-speed areas running eight-axis with servos at 80 cases per minute with a half-second cycle time, it's still EtherNet/IP. We just make sure to isolate our high-speed motion from other Ethernet traffic by using an Ethernet module with a ring topology."

Joey Stubbs, North American representative of the EtherCAT Technology Group (ETG, www.ethercat.org), adds, "The days of dedicated networks for motion, I/O and other tasks are effectively over, since all of these tasks can be serviced by one network simultaneously from one controller. Traditional motion protocols don't offer anywhere near the performance, diagnostics, ease of use, configuration and cabling of well-implemented, Ethernet-based protocols. This isn't just due to performance. It's also because machine-level communications now take advantage of consumer-based technologies such as Cat. 5/6 cabling, connectors, transceivers, standard NICs as masters, standard diagnostic tools, etc. This is instead of having to use special, costly hardware required by legacy protocols. This piggybacking of physical-layer components drives down the cost of systems and increases product selection."

PAI's palletizers have to quickly but gently stack and wrap cases of super-thin plastic bottles, and so they use robot arms and cranes on EtherNet/IP to replace traditional physical diverters.

So, how can machine builders choose the right type of Ethernet and related networking components to satisfy end users who need increased speed and throughput, better handling, increased flexibility and more open networking? Follow a good role model. There seem to be just as many Ethernet-based solutions as users have problems. You just have to get on the right train—and avoid the brawl in the club car.

Slice It or Stamp It?

Basic, vanilla Ethernet wiring and its pure TCP/IP came from IT and office realms, where data was blasted to all parts of the network and speed wasn't as crucial or possibly dangerous as on the plant floor. Ethernet's

more recent industrial protocols adopted increasingly intelligent switches and addressing to achieve determinism, and then adjusted their communication methods and rules for increased speed by prioritizing and synchronizing how they transfer data. In general, tightly dedicated Ethernet networking permits greater speed, but means less flexibility. Meanwhile, less-restricted Ethernet enables more flexible communications, but typically runs slower.

Historically, there were two main schools of thought about manipulating Ethernet to serve in higher-speed motion: time slicing and time stamping. To prevent message collisions, boost speed and achieve determinism, time slicing ensures that critical devices and functions are assigned specified time slots to transmit information. A managing node on the network handles time allocation, so the others can transmit without interference when it's their turn. Time slicing is used mostly by EtherCAT, Powerlink, SERCOS III and Profinet Isochronous Real Time (IRT).

The second method, time stamping, is based on the IEEE 1588 standard's Precision Time Protocol (PTP), which defines a method for sub-microsecond synchronization of the clocks in sensors, actuators and other terminal devices on a standard Ethernet-based network or other distributed application. It's used primarily by EtherNet/IP with CIP Sync and CIP Motion. IEEE 1588's basic function is to have the most precise clock on a network synchronize all the others, and then time stamp each data packet moving on the network.

Not surprisingly, the different methods of altering Ethernet for higher-speed motion have led to some arguments. The main debate

FRIESEN'S

WEIGH TO GO

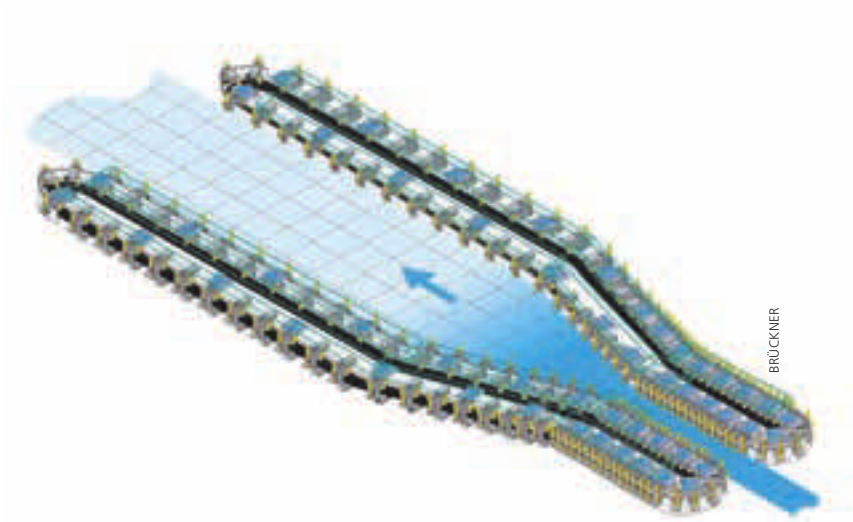
Figure 1: Friesen's washdown-capable checkweighers in its material handling systems use TwinCAT software and EtherCAT I/O terminals and servo drives to adapt to and serve in all areas of food production lines, as well as increase the checkweigher's speed by 31% and reduce downtime by 22%.

seems to be between the time slicers and the time stampers. The slicers say that time-stamped Ethernet is basically an Internet Protocol (IP) that's not dedicated enough to truly handle high-speed motion, and that it must run slower because its master device is always on and all data must run through it. However, the stampers counter that time-slicing might be quicker, but it risks losing data because its nodes can't run and communicate when the master device is talking.

Speedier Checks

Bickering aside, to give those food processors all the precise weighing data they need throughout their production lines, Friesen's (www.friesensinc.com) of Detroit Lakes, Minn., designed and developed its Mach-Series and F-Series machines to serve in earlier food manufacturing steps and adapt to a wide range of user requirements.

Mach-Series can run at more than 100 parts per minute, and has two high-speed, precision checkweighers and a high-speed, in-motion checkweigher. F-Series machines run at less than 100 ppm, and have in-motion checkweighers. Its washdown-capable systems can be deployed throughout food



SUPER STRETCHING

Figure 2: Brückner's linear motor-driven simultaneous stretching system (LISIM) machine pulls and stretches plastic film at 6.6 m/s between two opposing, ring-shaped rail lines, all coordinated by Powerlink, which reduced cycle time to 400 µs.

production lines, and its IP69K-rated systems are ideal for USDA-regulated plants (Figure 1).

"In the past, individual adaptation and scaling of the controls could be tricky tasks," says Kari McAllister, Friesen's product development director. "In my view, some of the major controls vendors in this space are too proprietary in nature, and fail to provide interfaces for third-party systems."

To eliminate these roadblocks, Friesen's adopted Beckhoff Automation's (www.beckhoff-fautomation.com) embedded PC with TwinCAT software and EtherCAT I/O terminals and servo drives to automate, accelerate and simplify its checkweighers. "We sought to process product weights faster and communicate to our reject systems at higher speeds," McAllister says. "EtherCAT can achieve update times for data from 1,000 distributed I/Os in only 30 µs, including terminal cycle time. Up to 1,486 bytes of process data can be exchanged with one Ethernet frame, which is equivalent to almost 12,000 digital inputs and outputs. The transfer of this quantity of data only takes 300 µs."

As a result, EtherCAT and open PC-based controls allowed Friesen's to decrease machine build time by 25%, cut installation time in half, reduce startup time by 30%, and reduce downtime by 22%. "Also, since Friesen's began using EtherCAT and embedded PCs, checkweigher system speed increased by 31%, which means we give our users much higher throughput and really differentiate ourselves, too," McAllister adds.

These gains are no surprise to ETG's Stubbs. "The highest-performance Ethernet-based protocols meet or exceed the capabilities of even the most demanding real-time motion control tasks," he states. "The best ones have leftover bandwidth to integrate other functionality, which previously had to be implemented in separate systems, such as 'non-motion' I/O, functional safety, data acquisition, and servicing of standard IP devices on the network such as for web thin clients. EtherCAT is capable of scanning 100 servo axes in 100 µs in one network, which sets it at the highest end of the performance metrics, while undercutting costs, eliminating the need for special cables or special infrastructure components, and allowing users to integrate functions over the same network, such as condition monitoring, functional safety and supporting other protocols."

ETHERNET ISN'T PRACTICAL FOR THE CRITICAL TASKS OF HIGH-SPEED MACHINE TOOLS, SUCH AS CONTROLLING SPINDLES AT THOUSANDS OF RPMS, BUT IT CAN HELP COORDINATE AXES, LOAD AND UNLOAD PARTS, MANAGE MATERIAL HANDLING, AND PERFORM OTHER SUPPORT TASKS.

Synch Lots of Axes

Besides enabling traditional speed, Ethernet-based protocols also need to accelerate the coordination required for multiplying numbers of axes, drives and other components. For instance, Brückner Maschinenbau (www.brueckner.com) in Siegsdorf, Germany, uses more than 700 clips to pull, stretch and heat set plastic film at 6.6 m/s through its simultaneous stretching system (LISIM) on two opposing, ring-shaped rail lines (Figure 2). The clips are pulled by a moving magnetic field, similar to the railway cars on a magnetic levitation train, which is generated by linear motors with 728 windings.

Current for these 728 zones along the 65 m long LISIM machine is supplied by 384 single- and dual-axis inverter modules in conjunction with 14 power supply modules and drives from B&R Industrial Automation (www.br-automation.com), and they're all synchronized via Powerlink.

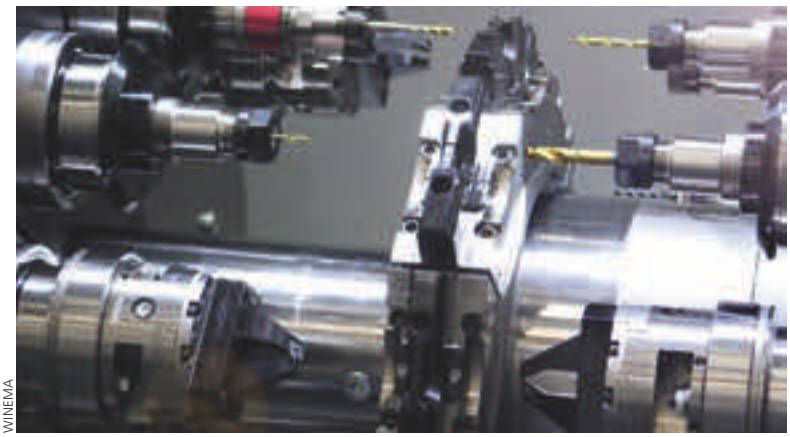
"LISIM's machine concept is based on linear motors, and we invented it more than 15 years ago, but it's experiencing a renaissance now because of increasing demand from the packaging and flat panel display industry for film with special properties," says Günter Oedl, Brückner's electrical engineering manager for automation and development. "However, the drive technology that we used up to now was getting on in years, and a new proprietary solution would have been difficult and costly."

Oedl adds, "This solution was possible because Powerlink allows precise synchronization of hundreds of network nodes, and simultaneously provides high data throughput. On one hand, we were able to reduce the cycle time significantly—it's now only 400 µs. On the other hand, we were able to move large chunks of software from the drives to a central drive controller. This also simplified servicing and software maintenance." B&R maintains that controlling 728 axes with a 400 µs update set a world record.

All 398 of the Acopos modules, both power supplies and inverters, in LISIM are synchronized by 12 of B&R's industrial computers. Each is equipped with three Powerlink cards, which control up to 13 modules. Using another Powerlink card, the computers communicate with each other or with a higher-level industrial computer that runs Brückner's motion control software. The plant control system, which is responsible for controlling LISIM's oven, is connected to this industrial PC via a Profibus interface.

Finally, Powerlink's short cycle times and minimized jitter allowed Brückner to position the zones along LISIM very closely. "The individual zones are grouped in a very homogeneous manner," Oedl says. "So the error tolerance is significantly less than a millisecond, which was stipulated by the application."

Robert Muehlfellner, B&R's automation technology director, adds, "The three fastest Ethernet-based protocols are Powerlink, EtherCAT and SERCOS III, and they're all fast and reliable enough for high-speed motion. They all can achieve fast update times between sub-500 µs and sub-1 ms, and they have high synchronization and minimal jitter. There are some technical differences, but their end results are the same, and so they're all good for 95% of machine applications."



WINEMA

Figure 3: Winema's RV 10 Flexmaster CNC-controlled rotary indexing machine for small, 2–23 mm parts uses SERCOS III and a CNC with decentralized intelligent electric and hydraulic drives.

Closer to Machining?

Aside from axes, one type of motion that Ethernet hasn't taken on yet is in the CNCs used in machining centers and related tools. Though Ethernet isn't practical for the critical tasks of high-speed machine tools, such as controlling spindles at thousands of rpms, it can help coordinate axes, load and unload parts, manage material handling, and perform other support tasks—essentially surrounding the core machining functions.

"Fieldbuses and Ethernet aren't fast or secure enough for CNC motion, and so we use our dedicated, fiberoptic Fanuc Servo

SHORTER CNC SETUP

FAST MOVERS

PRODUCTION AUTOMATION

WARP SPEED WRAPPING

Figure 4: Production Automation's Gantry Hybrid Palletizer uses integrated motion via EtherNet/IP to control a dual-head gantry crane and two robot arms with eight-axis servos to quickly, but gently, grab, position and build layers of cases of water bottles for palletizing in a 0.5 s cycle time at an overall rate of 80 cases per minute.

Serial Bus (FSSB) communication line, which runs at 150 MHz, to control servo and linear motors," says Paul Webster, engineering manager at Fanuc (www.fanuc.com). "Machine tool builders can use Profinet or EtherNet/IP to reach PLCs and control auxiliary devices, such as robotic loading or conveyors, or to reach the enterprise, but not for CNC."

However, though most CNC functions in machine tools remain as separate islands, Webster says they still added Ethernet ports and fieldbus links over the past 10 years; they download programs with Fanuc's open CNC automatic programming interfaces (APIs); and they use the XML-based MTConnect (www.mtconnect.org) standard to communicate with PLCs, monitor machine performance, and even download G-code files that the CNC machines use to perform projects.

Similarly, Winema Maschinenbau (www.winema.de) in Grosselfingen, Germany, introduced a CNC-controlled rotary indexing machine in a market usually dominated by cam-controlled equipment. Designed to handle small, 2–23 mm diameter workpieces, RV 10 Flexmaster employs an IndraMotion CNC-based system with decentralized intelligent electric and hydraulic drives from Bosch Rexroth (www.boschrexroth-us.com), which control the machine's 54 CNC axes, including 27 IndraDrive spindle drives. It basically consolidates CNC and PLC tasks into one IEC 61131-3 compliant module (Figure 3).

RV 10 Flexmaster's core consists of a vertical indexing table with 10 clamping stations. In each cycle, the motor-powered table rotates the workpieces to the next station. The machine's rotary indexing principle allows it to process nine workpieces in parallel in each cycle and achieve high throughput.

RV 10 Flexmaster uses SERCOS III, which provides profiles for smoothly integrating both drive technologies, and helps accommodate frequent changeovers. "Previously, cam-controlled

machines were unbeatably fast for large-scale series production," says Eckhard Neth, Winema's managing director. "However, we've been able to top this speed, and combine it with the advantages of CNC technology for increased flexibility. And combining the HNC with SERCOS III and IndraMotion has allowed us to improve our output by 20% compared to the previously available solutions."

Fast and Familiar Programming

To wrangle those increasingly thin and delicate plastic water bottles and build layers from widely varying case sizes, PAI developed its Hybrid Gantry Palletizer in 2009, and began building it last year, Davis says. Unlike a regular robot arm, this machine and its robots and crane can be thought of as a "Cartesian palletizer" that moves in the usual x, y and z planes, he says (Figure 4).

Besides maintaining high speed and providing softer handling, PAI found that using the eight servos via EtherNet/IP to move, manipulate and rotate the cases also eliminated a lot of mechanical assemblies such as diverters, case turners and conveyor rollers.

"However, the problem was that the initial programming for this new palletizer was more like using G-code and a teach pendant, which was hard for our customers to learn because they're more familiar with the ladder logic that palletizers usually employ," Davis says. "So we looked for a better way, and decided to use RSLogix 5000 software because we could program it so our users could understand it better and work in a more familiar environment. For example, customers say they can use logic modules in the software's DMAT toolkit to bring in tags for the servos, and easily set up and commission them without having to go to a second software program. Also, the servos' communications are isolated by the Ethernet module, which plugs into the Control Logix PAC, and creates a private network for that EtherNet/IP ring. We also knew this isolation was important because, in the past, we had a problem with a more open network and some users and devices trying to use the same IP address and being unable to communicate." cd

Even When You Lose Power, You Can Count On It

The RSM2800 Magnetic Encoder counts turns, measures angles down to the last degree, and remembers shaft positions without power

Don't try this with other encoders: imagine your machine with the RSM2800 inside both lose power and are still turning without power; when power is restored, the RSM2800 reports the correct position including counts that occurred with no power!

Besides new features, RSM2800 encoders provide the level of reliability, accuracy and absolute position sought in demanding applications like:

- robotics
- packaging machinery
- mining equipment
- medical equipment
- cable extension transducers
- forklifts

The RSM2800 is based on Novotechnik's patented multi-turn technology. This new technology combines advanced capabilities with mechanical simplicity to provide a lower purchase price of **under $100*** and lower lifetime cost.

* in quantity

RSM2800 Specifications:

- ☑ Multi-turn – up to 16 turns
- ☑ Sealed up to IP 67
- ☑ Resolution to <0.1°
- ☑ Diameter: 29 mm
- ☑ Shaft diameter: 6 mm
- ☑ Power-up position
- ☑ No gears, no optics, no batteries

For details on Novotechnik's **RSM2800**, call us or visit **www.novotechnik.com/rsm2800**

Novotechnik U.S., Inc. • 155 Northboro Road • Southborough, MA 01772
Tel: 508-485-2244 Fax: 508-485-2430

novotechnik
Siedle Group

From A to B With Mechanical Control

For Certain Applications, a Mechanical Solution Can Provide a Simpler, More Cost-Effective Answer to Motion Challenges

by Hank Hogan

FOR SOME MOTION control challenges, a simple solution might be the best. When movement is between only two points and is uncomplicated, then mechanical motion control often can be the smart solution. A look at several examples illustrates why, for some machine builders, keeping it simple isn't stupid.

Most colorful T-shirts sold at concerts or seen on the streets passed through a screen printing textile press. Years ago, multi-color presses used pneumatics with an indexing cylinder to rotate a carousel, with the number of stops dependent on the number of colors being printed. In an hour, a press might crank out 650–1,000 T-shirts, but that wasn't good enough.

"The market started to require more stable performance and quicker changeover of job setup," says Darek Tkacz, chief mechanical engineer at M&R Printing (www.mrprint.com) of Glen Ellyn, Ill. The company is a global supplier of screen printing textile and graphic presses.

> "The crank arm method is more forgiving in what it demands from a gearbox. Using this motion will allow us to go with a gearbox that's not as accurate and not as expensive."

M&R Printing's initial solution to this demand involved a direct-drive mechanism with a high-end servo motor and gearbox. The latter had less than 3 arc-min (0.05°) of backlash—an accuracy needed because it had to position a carousel within a stationary fork to lock it. For a 40 in. diameter carousel, the location had to be accurate within less than 0.002 in. The precision of the positioning directly determined the quality of the print, since the colors are layered atop one another.

Though the direct-drive approach worked and offered higher throughput, it was significantly more expensive than the pneumatic method. So M&R Printing opted to try another route—one that exploited mechanical motion control.

"Instead of a direct drive, we installed a crank-type index design," Tkacz says. "The crank is connected through a link to a capture fork, so that rotary motion is converted into linear motion back and forth."

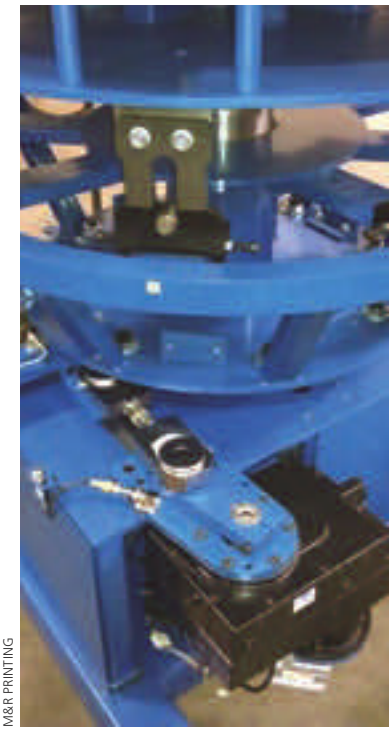
This works for the company's application, he adds, because the machines require only a stop and start point, a simple motion that always bounces between fixed locations. M&R Printing uses a design that has the crank with a 10° starting point and a 170° stopping point (Figure 1), although these two locations can be adjusted if needed. Experience during development revealed that the inertia of the largest and highest-output carousels was too great for this approach. Thus, those machines remained direct drive.

For smaller carousels, which can produce 900+ T-shirts per hour, the crank technique offers some significant advantages. For one, it allows M&R Printing to switch from a pneumatic index to a more cost-effective electric system with servo motor, Tkacz says, explaining that the servo motor made it easier to set up different parameters for different conditions.

"Most important for us was that we have been able to pre-program the speed of the machine for the different sizes of the printing pallets," he says. "Customers very often are changing pallet sizes a few times a day. With the pre-programmed pallet size speed of the machine, changeover is a very easy and fast process."

Another benefit is that the crank design boosts the throughput of some presses by about 50%, with little increase in price over the older technology. That is possible because the crank arm method is more forgiving in what it demands from a gearbox, Tkacz says.

"Using this motion will allow us to go with a gearbox that's not as accurate and not as expensive," he explains. "We've been able to choose a gearbox that can have 10 arc-min backlash and we can still achieve our linear accuracy for the indexing."



M&R PRINTING

SIMPLE CRANK

Figure 1: M&R Printing needs only a simple motion that bounces between fixed locations, so uses a crank index system instead of a direct drive to convert rotary motion into linear motion.

The success of the approach can be seen in the fact that M&R Printing has converted its product line almost completely to a crank-based design and away from pneumatic indexing, he adds. In implementing its design, the company specified gearboxes from Lenze Americas (www.lenzeamericas.com).

The biggest trend Lenze has seen is a push for increased energy efficiency, says Steve Greene, central regional sales manager. That has prompted Lenze Americas to move from a worm gear design to a helical gear. Doing so ups gear efficiency from 60% to 98%, and brings other benefits. "You can run the helical gear faster and it's more accurate," Greene says.

TECH-CON

ONE ROBOT'S ENOUGH

Figure 2: A mechanical rail system allows a robot to transfer seats from the assembly line to the drop-off point.

Flush Away Problems

Tekno (www.tekno.com), Cave City, Ky., produces conveyors and material handling solutions for the automotive and other industries. Cost is one reason the company sometimes turns to mechanical motion control, says Larry Mustread, chief operating officer.

Not only is a mechanical solution cheaper initially, it also can cost less to operate because of lower support costs and quicker time-to-repair. That's a consequence of the simplicity of the system and the ability to spot and diagnose problems quickly, Mustread says. "I know that it's going from point to point. If it starts losing that movement from point to point, it's easy to pick up that I'm getting wear somewhere."

Not all problems can be solved with mechanical motion control, though, Mustread notes. In particular, complicated motions are not good candidates. An

Not only is a mechanical solution cheaper initially, it also can cost less to operate because of lower support costs and quicker time-to-repair. That's a consequence of the simplicity of the system and the ability to spot and diagnose problems quickly.

articulated robot arm executing movement along several axes at once, he says, is not best solved by mechanical motion control. Neither is a motion path that

requires anything beyond moving from point A to B.

A leading maker of bathroom fixtures and hardware came to Tekno with a problem. The company needed to automate a packaging process to reduce costs so that it could compete with overseas manufacturers. Tekno streamlined the entire process. A requirement in the overall automated sequence was to flip over a toilet seat so that a label could be placed on it.

Because the motion was a simple 180° flip, Tekno elected to do it using a set of pneumatic grippers and a pneumatic rotary actuator. The former grabbed the seat, the latter rotated it, and then the grippers released, dropping the seat on an indexing conveyor that delivered it to labeling and packaging equipment.

One of the challenges was the variation among toilet sets, says Lance Gatewood, engineering manager. Some were long and elliptical, and others were short and round. They also arrived at the flipping station skewed or off-centered. Thus, the machine had to square the seat and flip it.

"We designed a two-stage gripper, where one side had a shorter stroke than the other," Gatewood says. "The short side would engage the seat first and push it to square it up, then the longer side would do the final squaring and gripping in one motion."

Another issue was cycle time. The entire process had to take place in less than 5 seconds. Hitting that mark meant using the lightest possible materials, consistent with the need for durability. After some experimentation, the Tekno engineering team settled on aircraft-grade aluminum for the platform, with aluminum and high-density polyethylene plastic (HDPE) for the arms and grippers. To get a fast enough turnover, they used flow control to speed up the rotary actuator return stroke, with a hydraulic shock absorber to bring everything to a gentle stop.

The final machine performed to specification and achieved its objectives, according to Gatewood. So too did the manufacturer for whom Tekno built the machine.

The offloading could not be handled by one robot. This was not a capacity problem, rather that the robot couldn't reach both assembly lines. One very expensive solution would have been to install robots for each line.

Many of the motors and gears that Tekno uses are from Nord Gear (www.nord-gear.com). Like others, Mark Jones, Nord vice president of engineering and marketing, sees a growing trend toward energy savings, which is achieved by tighter integration of motors and gearboxes.

Though mechanical motion control can be used for packaging or manufacturing, that is not primarily where it shows up, as illustrated by its use in Nord Gear. "We manufacture here, and we use our products to move our components around," Jones says. "So the material handling side is certainly the largest segment."

The Mechanical Slide

Another illustration of mechanical motion control comes from Tech-Con Automation (www.tech-con.com), a system integrator in Burlington, Ontario, that works with automotive and other manufacturers. Simpler solutions are often better solutions, notes Ron Heyden, vice president of sales and marketing. So, for simple movements that do not require multiple stops or a high degree of resolution, mechanical motion control might work best.

Consider the case of a large North American car seat manufacturer. The company had two assembly lines running in parallel, and the output of each needed to be placed on a shipping system pallet at the end of the line.

The offloading could not be handled by one robot. This was not a capacity problem, rather that the robot couldn't reach both assembly lines. One very expensive solution would have been to install robots for each line.

After studying the situation, the company's technical staff mounted the robot on a base and then put the assembly on linear bearings on a machined rail (Figure 2). With a simple air cylinder, they transported the robot between two spots.

Thanks to a hard stop and some built-in fine adjustment, Tech-Con was able to achieve accurate positioning so that the robot could serially service each of the two assembly lines. A shot pin held the robot in place while it performed its task, with sensors detecting the position of the robot and shot pin.

When all was said and done, this example of mechanical motion control paid off, Heyden concludes. "This simple system saved the requirement for a second robot," he says. CD

Reliability in Control Software

Can You Count on Your Mission-Critical Software? Operator Safety and Product Quality Depend on It

▲ BY WILLIAM GOBLE ▲

15TH ANNIVERSARY

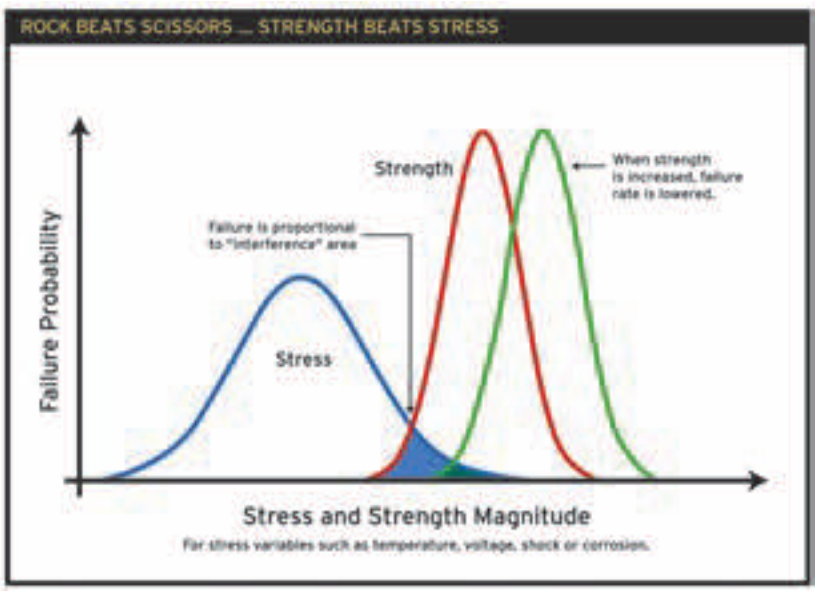
Continuing our anniversary retrospective of content we've created during the past 15 years, this time we offer up, as it originally appeared in May 2004, an article by a renowned industrial safety expert that cautioned about the steadily growing dependency that control systems had on software and, as a result, why it was imperative that we recognize the need to pay a lot more attention to software reliability. Eight years later, the incentive to do so remains vitally important.

Considering all the components used in today's generation of control systems, it's the root cause of hardware failure that gets studied most often. The root cause of software failure, on the other hand, is rarely studied or well understood.

In the field studies that have been conducted, some theories on what causes software failure have emerged, but even those are not widely known or followed by software engineers. Similarly, few practitioners know the rules of software reliability or take the time to understand how to create reliable software. Why? In part because software development tool producers work hard to make control software developers think it's easy to produce reliable software.

No one, however, can ignore the importance of software reliability, and as control systems grow in functionality and complexity, machine and production equipment builders must increasingly depend on software to carry the load.

We'll address these issues here and include examples of software failures, the root causes of those failures, some rules for avoiding those causes, and some guidance in evaluating software reliability in control system products.



The strength curve indicates the chances of any particular strength value in a collection of products. The area under both curves represents failure conditions. When the product design produces higher strength levels, failure probability decreases.

More Complex Control

Powerful new tools enable us to develop software-dependent control systems that are increasingly more complex. Software reliability, the ability of the software to perform its expected function when needed, is essential.

Yet, how often do we hear, "The network is down," or "My computer locked up—again," or "How long has this operator station been frozen?" Our experience with software is far from perfect.

As industry's dependency on software increases, so does the incentive to develop higher levels of software reliability.

HOOKED ON SOFTWARE

Control systems depend on software and this dependency is increasing. There is an important need to evaluate software reliability, but very little is now being done. The stress-vs.-strength concept helps identify the important factors in software reliability. Depending on the required level of software reliability, the following relevant areas and questions need to be considered:

Software Process
- Does a formal process exist for software creation?
- Do all software developers follow this software process?
- Has the process been audited by a third party such as FM or TÜV?
- Does the process conform to applicable standards such as ISO9000-3, DIN V VDE 0801/A1, IEC 61508?

Testability
- What execution variability factors exist in the system?
- Does the system involve multitasking?
- Is there fixed or dynamic memory allocation?

Software Diagnostics
- Does the design include program flow control?
- Is the program flow timed?
- How are the communication messages checked?
- How often is the data integrity checked?

Software Failure Happens

Consider why software fails. The next few examples offer some insight. The console of an industrial machine operator had functioned normally for two years. On one of a newly hired operator's first shifts, his console stopped updating the CRT screen and would not respond to commands shortly after an alarm acknowledgment. The unit was powered down and successfully restarted, finding no hardware failures.

With more than 400 units in the field and 8 million operating hours, the manufacturer found it difficult to believe that a significant software fault existed in such a mature product. An extensive testing procedure produced no further failures.

A test engineer visited the site and interviewed the new operator. At this interview, the engineer noted, "This guy is very fast on the keyboard." That small observation allowed the problem to be traced, and further testing revealed that if an alarm acknowledgment key was struck within 32 ms of the alarm silence key, a software routine would overwrite a critical area of memory and the computer would fail.

At another plant, an operator requested that a data file be displayed on the terminal and the computer failed. This was not a new request—the same data file had been displayed successfully on the system numerous times before.

The problem was traced to a software module that did not always append a terminating "null zero" to the end of the file character string. On most occasions, the file name was stored in memory that had been cleared by zeros written into all locations. Because of this, the operation was always successful and the software fault remained hidden. On the occasion that the dynamic memory allocation algorithm chose memory that had not been cleared, the system failed. This failure occurred only when the software module did not append the zero in combination with a memory allocation in an uncleared area of memory.

Consider a third example in which a computer stopped working after it received a message on its communication network. The message came from an incompatible operating system and, though it used the correct "frame" format, the operating system contained different data formats. Because the computer did not check for a compatible data format, the data bits within the frame were incorrectly interpreted. The events caused the computer to fail in a few seconds.

Many examples of software failure are documented, and most of them seem to contain some combination of events considered unlikely, rare or even impossible.

Stress vs. Strength

Reliability engineering provides the stress-vs.-strength concept. Failures occur when a stress is greater than a corresponding strength. Alhough this concept comes from mechanical and civil engineering and is most frequently applied to stress as a mechanical force and strength as a structure's physical ability to resist that force, the same concept is applicable to software reliability.

A.C. Brombacher applies this concept to electronic hardware reliability. In his book, "Reliability by Design," Brombacher notes that failures occur when some stress or combination of stressors exceeds the associated strength (susceptibility) of the system (see figure). Stress, or the combination of stressors, is represented by a curve of the probability of any particular stress value. The strength curve indicates the chances of any particular strength value in a collection of products. The area under both curves represents failure conditions. Within a product, strength is the measure of resistance to stress. When the product design produces higher strength levels, the product is much less likely to fail.

Many Potential Stressors

Electronic devices have many potential stressors. Environmental

and physical stressors include heat, humidity, chemicals, shock, vibration, electrical surge, electrostatic discharge, radio waves and others. Operational stressors include incorrect commands from an operator, incorrect maintenance procedures, bad calibration, improper grounding, etc.

Now, that makes sense for hardware, but how does this concept apply to software? What are the stressors on a software system?

Just as with hardware, software failure occurs when the stress is greater than the strength. The strength of a software system can be measured by the number of software faults or design errors (bugs) present, the testability of the system, the amount of software error checking, and online data validation. The stress of a software system is dependent on the combination of inputs, input timing and stored data seen by the CPU. The inputs and the timing of inputs could be a function of other computer systems, operators or both.

Testing revealed that if an alarm acknowledgment key was struck within 32 ms of the alarm silence key, a software routine would overwrite a critical area of memory and the computer would fail.

Improve Strength and Reliability

Higher levels of software reliability result from improving software strength. Most of the efforts in this area have focused on improving the software development process and removing software faults. Because human beings create software and also make mistakes, the design process is never perfect.

Companies expend many resources to establish and monitor the software development process. These efforts aim to increase strength by reducing the number of faults in the software. This approach can be very successful, depending on implementation, and attempts are being made to audit the effectiveness of the software process. For example, the

ISO9000-3 standard establishes required practices.

The Software Engineering Institute (www.sei.cmu.edu) created a five-level software maturity model, wherein Level 5 represents the best process. In addition, companies in regulated industries such as pharmaceuticals audit software vendors to ensure compliance to internal software reliability standards. By reducing the number of faults in software and thereby increasing its strength, these efforts have begun to improve software reliability.

Another factor that influences the number of faults in a software system is its testability. Software testing may or may not be effective, depending on the variability of execution. A test program cannot be complete, for example, when software executes differently each time it is loaded. In this situation, the number of test cases explodes to virtual infinity.

Execution variability is increased with dynamic memory allocation, number of CPU interrupts, number of tasks in a multitasking environment, etc. All of these factors need to be considered when the potential reliability of software is evaluated. Increasing the amount of variability such as multitasking or dynamic memory allocation decreases testability and indicates lower strength and reliability.

Software strength also increases based on several important factors referred to as software diagnostics, in primarily two ways. First, software diagnostics can reject potentially fatal data. Second, software diagnostics can do online verification of proper software execution. In fact, international standards for safety critical software (DIN V VDE 0801, IEC 61508) specify software diagnostic techniques such as program flow control and plausibility assertions. These diagnostics are required in safety critical software approved by recognized third parties such as FM in the U.S. and TÜV in Germany.

Most of the efforts in software reliability have focused on improving the software development process and removing software faults. Because human beings create software and also make mistakes, the design process is never perfect.

One software diagnostic technique is program flow control. In this procedure, each software component that must execute in sequence writes an indicator to memory. Subsequently, each software component verifies that necessary predecessors have done their job. When a given sequence finishes, verification is done to confirm that all the necessary software components have run in the proper sequence. When the operations are time-critical, the indicators can include time stamps. The times are checked to verify that maximums have not been exceeded.

Plausibility assertions verification is another software diagnostic. While program flow control verifies that software components have executed properly in sequence and timing, plausibility assertions check inputs and stored data. The proper format and content of communication messages are checked before commands are executed. Data is checked to verify it is within a reasonable range. Pointers to memory arrays also must be within a valid range for the particular array.

All these techniques are considered online software testing. When a software diagnostic finds something not within the predetermined valid range, there usually is an associated software fault. A software diagnostic reporting system records program execution data and fault data. This provides the means for software developers to identify and repair software faults rapidly. This increases the effectiveness of testing before a product is released. Assuming the data is effectively stored, these methods also allow more effective resolution of field failures when they occur. ▲

William Goble is principal partner with Exida (www.exida.com), providing safety training and consulting services for users of industrial controls and automation. With more than 30 years of experience, he is a recognized expert in programmable electronic systems analysis, safety and high-availability automation systems, and market analysis.

References

1. Avizienis, A., "Systematic Design of Fault-Tolerant Computers," SafeComp '96, Proceedings of the 15th International Conference on Computer Safety, Reliability and Security, Springer-Verlag, New York, N.Y., October 1996.
2. Brombacher, A.C., Reliability by Design, John Wiley and Sons, New York, N.Y., 1992.
3. Humphrey, W.S., Managing the Software Process, Addison-Wesley, Reading, Mass., 1989.
4. Nuefelder, A.M., Ensuring Software Reliability, Marcel Dekker, New York, N.Y., 1993.
5. Goble, W.M., Control Systems Safety Evaluation and Reliability, ISA, Research Triangle Park, N.C., 1998.

Made in the Shades

THINGS USED TO BE simpler. A color sensor did its basic, low-cost, red-green-blue (RGB) sensing jobs to distinguish items such as bottle-cap colors. A vision system used its expensive cameras for higher-level image gathering and processing to differentiate subtle shades. Now both technologies are diversifying. Color sensors can distinguish shades better, and vision systems are dropping in price to do simpler tasks.

"Most color sensors didn't do true color comparisons," says Jack Moermond, market manager for object detection and photoelectronics at Balluff (www.balluff.com). "The most-popular binary-output sensors took in percentages of red, green and blue, and output them to PLCs to indicate color presence or go/no-go conditions. Now, a lot of customers want to compare or sort different shades and textures. This capability used to be very costly. Also, color sensors are a lot easier to configure now."

The color sensor market hasn't performed especially well lately because vision systems have taken over some applications, according to Steve Nylund, CEO of Delta Computer Systems (www.deltacompsys.com). However, both sensors and visions systems have suffered because they're often used in quality control projects that were put on the backburner during the recent recession.

"Our specialty is color sensors that can handle textured materials and surface variations, and so we've been stable because this is where lower-cost sensors can't perform as well," Nylund explains. "We also have a large 0.5 $in.^2$ sensing area and a wide, diffuse lighting pattern that smoothes out our sensing process. Our sensors have been getting more sophisticated, and now we can teach them up to 15 colors with our ColorSense software. We gave the software the ability to more accurately show to the user what the sensor sees."

Michael Turner, product manager for photoelectric sensing at Pepperl+Fuchs (www.pepperl-fuchs.us), adds, "There's no middle-of-the-road color sensor. Either it's a basic type that's relatively low-cost with good performance but very limited in functionality, or it's manufactured by a color sensor specialist and it's extremely costly. I think there is room for innovation in the middle-of-the-road category."

Pepperl+Fuchs recently introduced a family of contrast sensors that is a special version of a color-mark sensor/contrast sensor, and incorporates IO-Link networking functions that can be used to establish an RGB benchmark, copy custom settings to multiple devices, and save changeover time.

"With the complexities of automotive interior assemblies (door panels, head liners, cockpits, seats, etc.), the possibility to install an incorrect component can be relatively high unless assembly is verified," says Victor Caneff, automotive business manager at Banner Engineering (www.bannerengineering.com). "Our color sensor can verify that an installed component matches the color scheme of the interior design. Using a white LED light source, the sensor analyzes reflected light from the surface of the target. By comparing the red, green and blue content present in the reflected light, the sensor determines if the part matches a stored value from a known good sample programmed into its memory. Also, intensity thresholds can be established to detect if the part is the correct shade of the color."

> **"Customers want to compare or sort different shades and textures. This capability used to be very costly."**

Even in higher-tech vision systems, Cognex (www.cognex.com) agrees, users want high resolution and to differentiate between shades, so they want 24-bit color processing software and tools to do it. "We came up with a color camera with 1,600x1,200-pixel resolution and Match Color and Extract Color tools in our Insight vision software to identify colors more accurately," says Narayan Subramaniam, principal product marketing manager for Cognex's vision systems.

Rick Bondy, product manager for registration solutions at Sick (www.sickusa.com), says that besides teaching shades and setting tolerances, color sensors are aided by stronger LED light sources that allow longer sensing distances, and by its own 30x10 mm rectangular illumination area instead of the usual 18 mm circular light spots. Sick's sensors can identify and teach up to four colors.

"Many users are upset by vision systems that are costly, complex and hard to set up," Bondy says. "So, in the last three or four years, suppliers have been making them easier to integrate, maintain and apply." CD

Jim Montague · jmontague@putman.net

I/O Solutions Cross the Board

OEMs Rely on a Wide Variety of Mounting and Connectivity Routes

INDUSTRIAL MANUFACTURING is a world that continues to demand more flexibility and more customized solutions, with less of a one-size-fits-all approach. So it shouldn't be a surprise that machine builders are all over the board with what kinds of I/O solutions they need.

Control Design surveyed machine builders recently about their I/O systems and terminal blocks, and found that they were often pretty evenly divided on a number of points. For example, about one-third of respondents (32%) say their I/O is mostly centralized, with some remote/distributed; while another third (30%) are using remote/distributed I/O, with some centralized. A quarter of them are using mostly or entirely centralized/rack-mounted I/O systems, with just under 13% using mostly or entirely remote/distributed I/O. Of those using remote I/O, they are predominately (almost 73%) mounted in cabinets, with 25% machine-mount varieties.

Machine builders responding to our survey are also using a wide range of I/O connectivity options. Asked which types of connectivity they mostly use, more than half (almost 58%) responded with 4–20 mA, and also more than half (54%) indicated hardwiring is high on their list. Close to 45% ranked some kind of Ethernet connection high as well. Other usage includes process fieldbus (30%), device-level digital networks (30%), serial (26%) and wireless (12%).

Choosing controller technology is a less diplomatic affair, however. Almost three-quarters (74%) of respondents say their machine controller technology is PLC. That's followed by embedded control at a distant 14% and PCs at 7%. Close to two-thirds are specifying and purchasing their I/O bundled together with the controller.

CERTIFIABLE MODULES

Brad HarshIO Profinet I/O modules are PNO-certified to meet Profinet specifications for conformance class B. Fast Start-Up (FSU) technology connects industrial controllers to I/O devices, and Simple Network Management Protocol (SNMP) support extends module diagnostics of network functions such as port status messages. Media Redundancy Protocol (MRP) increases data reliability.
Molex; 800/225-7724; www.molex.com

KEEP OLD I/O

G4EB2 I/O processor integrates an existing, legacy Pamux G4 digital I/O system with modern Snap PAC controllers and PAC Project software over Ethernet without changing existing I/O or field wiring. G4EB2 directly replaces a 32-channel digital I/O processor in a legacy Pamux system.
Opto 22; 800/321-opto; www.opto22.com

CAT QUICK

GX-Series EtherCAT block I/O is combined with the NJ-Series machine automation controller with digital, analog and pulse I/O modules and microsecond On/Off times with EtherCAT's cycle times. The block I/O has been certified fully compatible by the EtherCAT Technology Group.
Omron Automation and Safety; 866/88-omron; www.omron247.com

MORE ASI I/O

G11 AS-Interface I/O modules include two analog outputs each—one for 0–20 mA operation for flat cable connectivity and one for 0–20 mA operation with an M12 round connector. A third module has four analog outputs of either 0–20 mA or 0–10 V for flat cable connectivity powered by AS-Interface or an auxiliary power source. The output type of each module can be selected by DIP switch.
Pepperl+Fuchs; 330/486-0001; www.pepperl-fuchs.us

JUMP 3 TIMES

2002 Series Topjob S terminal blocks carry three jumper slots for control cabinet flexibility. DIN-rail disconnect/test with mechanical interlock, mini-automotive blade-style fuse and fuse disconnect with pivoting holder accommodate one output and two input potential commoning. The third jumper permits test and measurement via plugs/taps without distributing machine wiring.

Wago; 800/din-rail; www.wago.us

QUICK RESPONSE

Axioline real-time I/O system has a response time of less than 1 µs per I/O module. It uses push-in technology for quick, tool-less connection; operates in a range of -25 to 60 °C; and has extended protection against EMC with adjustable input filter times.

Phoenix Contact; 800/322-3225; www.phoenixcontact.com

REMOTE I/O

EtherNet/IP-based remote I/O modules include Adam-6150EI with 15 channels of isolated digital I/O; Adam-6151EI with 16-channel isolated digital input; Adam-6156EI with 16-channel isolated digital output; and Adam-6160EI with six-channel relay output. They are designed with 2,500 Vdc isolation protections and are resistant to field interference.

Advantech Industrial Automation; 800/205-7940; www.advantech.com/ea

---

PLENTY OF ZIP

Zipport heavy-duty, multi-wire connectors in 3A, 6B, 10B, 16B and 24B frame sizes and polyester powder-coated aluminum alloy housings have a standard profile, and PG threaded cable passages; PG thread to NPT adapters are optional.

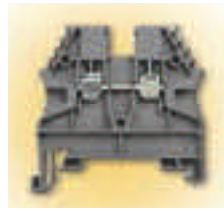
AutomationDirect; 770/889-2858; www.automationdirect.com

WILL YOU CRIO?

cRIO-908x reconfigurable I/O (RIO) has Xilinx Spartan-6 FPGAs and optional Windows Embedded Standard 7 (WES7) OS configuration. The systems have two Gigabit Ethernet ports, an MXI Express port, four USB ports, RS-232 and RS-485 serial ports, as well as a CPU eXpansion Module (CXM).

National Instruments; 800/258-7022; www.ni.com

FEED IT THROUGH



DIN-rail-mountable AVK feed-through, screw-connection-style terminal blocks with vibration-resistant wire clamps have a plastic housing made from polyamide 6.6 thermoplastic resin with a UL 94 V2 rating for 105 °C. Available accessories include end plates, end brackets, cross connectors for bridging, and marking tags.
Omega Engineering; 203/359-1660; www.omega.com

SAVE ON I/O

Bulletin 931 analog signal conditioners convert a range of device signals to a standard 4–20 mA signal. Systems that transmit thermocouple signals over significant distances can take advantage of the signal conditioners to help reduce additional I/O and cabling costs with less chance of signal deterioration.
Rockwell Automation; 414/382-2000; www.rockwellautomation.com

IS I/O

Simatic ET 200iSP I/O system has three modules to accommodate safety standards IEC 61508 to SIL 3 or ISO 13849-1 to PLe e. Sensors and actuators connect directly to a bus system and the I/O system can be mounted in a non-explosion-proof cabinet.
Siemens Industry; 800/241-4463; www.usa.siemens.com

SUPPORT YOUR LOCAL MARSHAL

WMF 2.5 terminal series for DCS marshalling applications features feed-through, fusing and quick disconnects in a single profile. The terminals have an integrated shield or ground (PE) connection, and three separate jumpering channels for parallel and series jumpering.
Weidmüller; 800/849-9343; www.weidmuller.com

CONNECT THE CUBE

Backward-compatible Cube67+ connects up to 32 I/O modules with a reach to 60 m, and has protocol support for EtherCAT. Bus nodes include an integrated Ethernet switch, built-in T-coupler for power, and IP selection window. Modules include analog I/O, digital I/O, RTD, thermocouple, and high-speed counter.
Murrelektronik; 770/497-9292; www.murrinc.com

DAQ AND MORE

MAQ20 for industrial data acquisition and control is a family of programmable, multichannel signal conditioning I/O modules and communication modules. They mount on standard gull-wing DIN rail. Each I/O module has a 1,500 Vrms isolation barrier between the field-side and system-side wiring.
Dataforth; 520/741-1404; www.dataforth.com

ISOLATE AND CONVERT

DIN-rail-mount TT230 signal conditioning I/O modules are 12.5 mm wide and have a USB connection PC configuration. Models isolate and convert thermocouple, RTD, voltage or current input signals to a 4–20 mA output. They are loop-powered and support both source or sink output wiring connections.
Acromag; 248/295-0865; www.acromag.com

SCALABLE

ST Series modular distributed I/O system operates as a slave device station for CC-Link or Profibus device-level networks.

It includes a head unit, power supply and on DIN rail to form a remote system, or node, and has a scalable architecture that accepts mix-and-match I/O configurations and I/O concentrations from two to 16 I/O points.
Mitsubishi Electric Automation; 847/478-2100; www.meau.com

TOUGH CONNECTOR

Stainless steel junction boxes have FM approval for Class 1, Div. 2, Groups A, B, C and D hazardous locations. Rated IP67, there are six- and eight-port models for use with M12, 7/8 in. or minifast connectors. Stainless steel junction boxes are designed to house existing circuit boards and receptacle housings.
Turck; 800/544-7769; www.turck.us

SOME NEED IT HOT

EtherCAT I/O devices with Fast Hot Connect reduces the connection time for these change-overs to 1 s, increasing productivity as a result of changing topologies via direct plug-and-play coupling or decoupling during operation. WinCAT automation suite supports Fast Hot Connect on the master side.
Beckhoff Automation; 952/890-0000; www.beckhoffautomation.com

DIRECT I/O

LioN-M I/O EtherNet/IP modules have 16 digital I/O channels with universal input/output functionality for direct connections between sensors/actuators and control systems. The universal modules (16DIO universal) provide 16 digital inputs and 16 digital outputs in any desired combination without individual parameterization.
Belden/Lumberg Automation; 717/217-2299; www.lumberg-automationusa.com

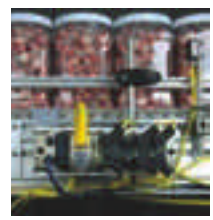
CONNECT THERMOCOUPLES

Spiro-TC three-channel remote thermocouple modules can be powered by USB, 6–50 Vdc or Power over Ethernet (PoE). Support for K, J, N, S, T, E and R thermocouples is available to 0.25 °C resolution with ±2.0 °C accuracy with no calibration required. 14-bit measurement includes built-in cold junction compensation and open thermocouple detection.
SoftPLC; 512/264-8390; www.softplc.com

MASTER DISTRIBUTOR

microNCS provides Modbus RTU (RS-485) master capabilities, cost-effective distributed data acquisition and, with expansion I/O, control capabilities. One or both of the microNCS's Modbus RTU ports can be configured to poll other RTU slaves with all of the network polling functions of a typical Modbus master. An industry-standard OPC interface delivers plug-and-play integration with popular PC-based HMI and SCADA software packages.
Moore Industries; 818/894-7111; www.miinet.com

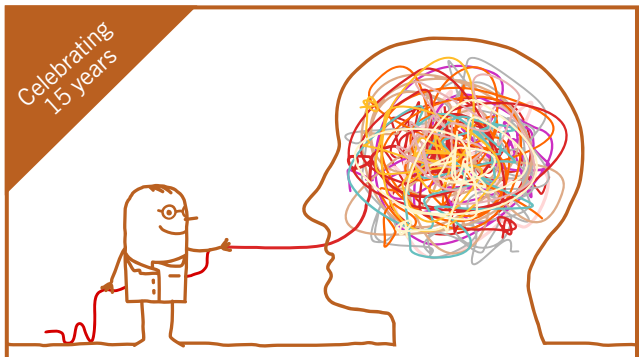
DISTRIBUTED AND MODULAR



Distributed modular I/O with IP67 protection and industry-standard connectors uses standard three-conductor cables. Up to four slave devices can be connected to each master block, which communicates via industrial Ethernet to the controller. With point-to-point IO-Link, the system is fieldbus-independent and vendor-neutral.
Balluff; 800/543-8390; www.balluff.com

CONNECT AT THE SUMIT

PXM-UIO96-2 96-line digital I/O module offers PCI Express expansion on a PC/104-sized module enabled by stackable high-speed Sumit connector. It uses a Lattice Semiconductor FPGA with a superset of the company's universal I/O controller cores. Each I/O line is programmable for input, output, or output with read-back operation.
WinSystems; 817/274-7553; www.winsystems.com



Let Us Pick Your Brain

In upcoming issues of Control Design, we'll explore subjects that include:

- What the real differences are among the various Ethernet flavors of fast motion buses
- The threat of electronics to pneumatics and hydraulics as power sources
- Where relays fit in today's programmable machine control
- How robots fit into machine design
- What's your understanding of what a PAC really is?
- Advice for building your panels in-house
- Step up and talk to us about these or any other machine automation topic that's affecting the way you do your job today and those that might affect it tomorrow.

We want to hear the thoughts and experiences of our machine builder and system integrator readers.


Joe Feeley
editor in chief
jfeeley@putman.net


Dan Hebert
senior technical editor
dhebert@putman.net


Aaron Hand
managing editor
ahand@putman.net


Katherine Bonfante
digital managing editor
kbonfante@putman.net


Jim Montague
executive editor
jmontague@putman.net

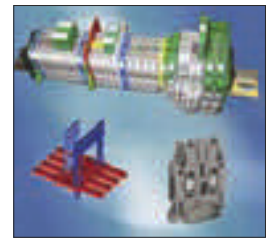

Sarah Cechowski
associate digital editor
scechowski@putman.net

Call us at 630/467-1301

or start the conversation in our Machine Builder Forum on

ControlDesign.com

BRIDGE BUILDER



CBC terminal blocks are designed to address control and power distribution applications where circuit bridging of two to 50 positions is required for consecutive, alternate and numerous terminal blocks in one assembly. Each terminal block can accept one or two bridges/jumpers.

ASI; 877/650-5160; www.asi-ez.com

SLIO NOT SLOW

Compact SLIO I/O system for systems 100V, 200V, 300S and 500S have a staircase-shaped wiring layer, clear readability of channel states, protection against reverse polarity, backplane bus at 48 MBps, and 20 µs response time. The decentralized I/O system is a space-saving, thin design with a simple two-component setup.

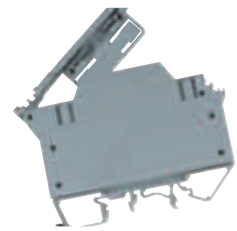
Vipa USA; 678/880-6910; www.vipa-usa.com

DECENTRALIZE THE I/O

With IP67 protection, X67 I/O modules can be installed on the machine, and can span 100 m between modules. Users can set parameters for the digital inputs and outputs and connect to all standard fieldbuses.

B&R Industrial Automation; 770/772-0400; www.br-automation.com

FUSE THE CIRCUIT



WTB2-FB130L IEC fuse holder terminal blocks have a current rating to 30 A, and accept ¼ x 1¼ in. fuses. They have a built-in LED circuit to indicate when the fuse blows and funneled wiring entry with finger-safe IP20 terminals. Marking system allows for fast and easy circuit identification.

c3controls; 724/775-7926; www.c3controls.com CD

What Exactly Is a PAC?

"WE'VE USED BASIC PLCS and I/O for machine control for a long time. Our machines have to do more than before, and we need more connectivity options and a more COTS, standards-based approach to hardware and programming. Some customers are on the PAC bandwagon and think it's the next step for them and us. There are different opinions of what a PAC is. PLC vendors say they make PACs. So do PC-based control suppliers. Does it matter?"

—From August '12 Control Design

ANSWERS

Mashup Control

A programmable automation controller (PAC) can be described as a "mashup" between a PC and a PLC in that it typically offers the benefits of both in a single package. Therefore, it's becoming more common that PLC vendors position their higher-end controllers as PACs—largely because their higher-end products incorporate more connectivity options and broader control capabilities than their PLC lines.

In your situation, the key point is what you state in your question: connectivity options and commercial off-the-shelf (COTS) technology. PACs offer both out of the box. Connectivity options like Ethernet are standards-based and therefore deliver on the COTS promise. For example, standard, readily available components like networking hardware will more easily and cost-effectively interface with a PAC.

In contrast to PC-based control, more often than not, a PAC will have lower running and maintenance costs. One advantage of a PC-based controller is faster computing speed and greater data storage area, but not necessarily faster I/O access. Will your machine accommodate a larger PC-based controller? Is the environment around the machine harsh in any way? PACs are usually smaller and more robust.

Taking all this into account, you must consider your customer requirements, weigh in your machine constraints, and choose the best upgrade. Many options certainly exist, and ideally, you should choose a vendor that provides multiple controller options (both PAC and PC-based for example).

Given the rising use of smartphones and tablets in industrial automation, you should also be looking at a platform that will ease adoption of this technology into your machine. Internet, wireless and cloud-based storage solutions are all growing in use. Select a PAC, PLC or PC that can support these technologies and protocols in a secure manner.

So, does it matter? Yes, I believe so. But, it's your current and future customers that will ultimately help you decide.

BEN ORCHARD, systems engineer,
Opto 22, www.opto22.com

The One That Suits Your Needs

PLC is a term generally used to describe a general-purpose controller ideal for controlling standalone, discrete machinery or processes. A PAC refers to a controller that offers multi-discipline control. For example, a PAC might offer the ability to execute complex motion instructions as well as possess integrated safety functionality, while a PLC typically would offer only logic control.

Some PC-based control suppliers might offer PACs, but not all PC-based controllers are PACs. The terminology is often interchanged, even among the most savvy machine builders.

Here are some questions to help guide you:

1. Does your application require multi-discipline control (motion, safety, drive, process, etc.)?
2. Do you have panel size constraints that should be considered?
3. What is the expected lifecycle of the machine?
4. Is rugged packaging required?
5. What networks will you be using for your machine design?

Overall, the terminology is less important than selecting the controller and vendor partner that best meet your specific needs.

DEXTER LEONG, product manager, CompactLogix,
Rockwell Automation, www.rockwellautomation.com

A Controller by Any Other Name…

I think the concept of a PAC, while technically defined, is more of an all around automation "solution" piece of hardware, rather than the simple I/O controller we're used to in PLCs. It used to be that the control system ended with the PLC, and users interacted with an HMI to report this to the office, where the numbers were punched in again. Then we added SCADA, and had to move information out of the PLC and into a more PC-based environment.

It's inevitable that the next step of control systems would be to integrate a more tight-knit linkage with the systems where the information needs to flow, and often that information needs to flow to an IT-controlled system. So really, I think PLCs are becoming the less-expensive alternative to a PAC and becoming PACs in all but name, and PC-based control systems are "hiding" their PC background and moving toward a form factor and user interface much more akin to the traditional interfaces we're used to in the controls industry. Really, I don't think it matters.

What does matter is that you find the proper tool for the job, and more and more we're seeing connectivity options increase across the board. Standards-based programming gives us the ability to teach the next generation of controls engineers how to program independent of manufacturer, and often to pick and choose what language is the best for the particular programming option. It's an exciting time to be in this industry!

DAN FENTON, control and software product marketing, Phoenix Contact, www.phoenixcontact.com

Often Not Required

The "Real Answer" is that is doesn't really matter. PAC is simply a term used by some suppliers to describe what others would call PLCs and PC-based controllers. In general, it refers to hardware that goes above the simple ladder logic found in classic/basic PLCs, and that can incorporate higher-level control such as PID and sequence control.

Nowadays, the majority of PLCs offer this higher level of functionality, with standard programming languages, connectivity for multiple bus systems, and functional expansion through add-on modules. PC-based systems offer similar functionality, with a PLC kernel and additional interfaces to allow integration of standard PC technology and peripherals.

PACs often offer a higher level of performance, integration of higher-level PC languages and visualization possibilities combined on one system. This convergence of technologies provides benefits of consolidation of tasks into a single system, but brings with it an inherent increase in complexity.

In the end, today's PC-based and PLC offerings can both handle most applications. The one that is right for you depends on your specific application, functional requirements and knowledge. Both types of systems come off-the-shelf with industry-standard communication and engineering, and offer enough flexibility that proprietary solutions are far more costly and often not required.

SYDNEY MCLAURIN JR., PC-based automation marketing manager, Siemens Industry, www.usa.siemens.com

Some Things Matter, Some Don't

There certainly are varying definitions of what a PAC exactly is vs. the traditional PLC. As a machine builder, the primary concern shouldn't be in the terminology. Instead, consider other aspects when faced with having to add the features listed in the question. What level of functionality and performance is required for controlling a particular application? Is there an automation platform available that can offer right-sized and cost-efficient hardware for not just a single machine, but an entire machine portfolio? Can the automation platform easily be customized with off-the-shelf products to adapt to changing needs and can it do that while reusing any existing application software? Is the hardware and software built on a modern architecture that ensures both innovation and long-term availability?

From my perspective, the main difference between a PAC and PLC is that a PAC provides better control of the timing of the application program(s) that run on the controller. In a PLC, the program typically runs in a continuous mode, meaning that as soon as one scan finishes, the next one starts. The advantage is that small programs run fast even on low-end hardware, but as the program grows, so does the program runtime, thus slowing down reaction times. Another disadvantage is that as different program conditions execute more or less code per scan, the program execution time varies, leading to inaccuracies that will have a negative impact on the repeatability from one machine or product cycle to the next.

On a PAC, the program will run in a scheduled cyclic mode. Here, an underlying real-time operating system will schedule program(s) in cyclic tasks with different priorities and cycle times independent of the program execution time. This allows the application to be separated into programs running in a fast cycle time for time-critical tasks (e.g. digital I/O processing) and slower cycle times for less time-critical tasks (e.g. PID temperature control and HMI logic) on the machine. What might look more complex at first

really offers much greater flexibility to any machine builder in designing the application software and achieving better production accuracy and repeatability due to a constant timing.

Another common difference between a PAC and a PLC is the ability to incorporate additional functionality like motion and robotic control, remote or onboard visualization, file handling, web server, etc., on the same piece of hardware, allowing consolidation of multiple controllers into a single one and offering value-adds in terms of diagnostics and data collection capabilities.

This is the area where the lines from PLC to PAC and PC begin to blur depending on what functionality the underlying hardware and operating system architecture of the controller allows. Some manufacturers are using microcontroller- or RISC-based architectures, which are in essence a "PLC on steroids"—faster and with better timing but not too much more functionality common in a PC-based architecture.

Some PC manufacturers come from the other end—taking an industrialized PC with a real-time operating system and maybe a second OS like Windows and calling it a PAC or "soft PLC." Such systems offer great performance and additional functionality, but can't necessarily be scaled down cost-efficiently for lower-end applications because of the PC hardware overhead. They might also lack features common in a PLC like non-volatile memory to retain tag information through a power cycle.

ROBERT MUEHLFELLNER, director of automation, B&R Industrial Automation, www.br-automation.com

PAC or Enhanced PLC?

It doesn't really matter what you call the controller; the real issue is the functionality you need and how much are you willing to pay for it. PLCs have been enhanced with extra hardware and software over the years to handle more than their original function of sequential logic. PACs were introduced as some companies saw a more cost-effective way to handle motion control, visualization, more advanced calculations, and connectivity to supervisory and ERP/MES systems.

These alternative suppliers to traditional PLC vendors realized that they could provide all of these extra functions without the extra cost of additional hardware and software by using a powerful industrial PC processor as the core of their controller. These powerful devices were called PACs at first to differentiate them from "enhanced" PLCs.

Unfortunately, some PLC vendors answered this development by calling their enhanced PLCs "PACs" as well, leading to confusion with the term. While PC-based solutions use standard, off-the-shelf technologies and manage more functions in software, the PLC-based PACs tend to rely more on proprietary add-on hardware.

Again, you must look at the cost and functionality you need, and choose the best technology for your applications. In general, you will get more advanced functionality, higher performance and a lower cost if your controller uses a PC-based design, as it can handle all of the tasks within one CPU and with one software package. On this note, the advent of multicore processor technology in PC-based control technologies has given a considerable lead to the controllers that incorporate them over their traditional PLC-based peers. Also consider that less hardware and software is normally a good engineering principle for improved lifecycle management.

The most important consideration is how it can deliver enhanced functionality while also having the best price-to-performance ratio.

GRAHAM HARRIS, president, Beckhoff Automation, www.beckhoffautomation.com

DECEMBER'S PROBLEM

OUR PRINTING MACHINES have widely distributed I/O and sensors, and we could save money by connecting some of these points via a wireless network. We hesitate to proceed because we're not sure where the current wireless standards are headed, and we don't want to implement a supposed standard that will fall out of favor in a few years. Is there currently a leading standard that would be a safer pick for the future?

SEND US YOUR COMMENTS, SUGGESTIONS OR SOLUTIONS FOR THIS PROBLEM. We'll include it in the December '12 issue, and post it on ControlDesign.com. Send visuals if you'd like—a sketch is fine. Email us at RealAnswers@putman.net. Please include your company, location and title in the response.

HAVE A PROBLEM YOU'D LIKE TO POSE to the readers? Send it along, too.

TUBE-FRIENDLY

Type 1009 2.5 and 3.5 in. Duralife SS pressure gauges, with full-scale ranges to 7,500 psi, are available with a 0.25 in. or 6 mm OD tubing fitting for direct connection to pressure tubing systems via industry-standard, ferrule-type mechanical grip couplings.
Ashcroft; 800/328-8258; www.ashcroft.com

THIRD-GEN VISION

4Sight GP industrial computer for machine vision is powered by a third-generation Intel Core processor for real-time, high-definition H.264 encoding offload. It accommodates full-height, half-length frame grabbers for analog, Camera Link, CoaXPress, DVI or SDI video capture. It integrates Gigabit Ethernet and USB 3.0 interfaces, which provide native support for capturing from GigE Vision cameras and upcoming USB3 Vision cameras.
Matrox Imaging; 514/685-2630; www.matrox.com/imaging

ISOLATED FOR SAFETY

ISM-TRM-ISO-IN provides 24 lines of optically isolated and digitally debounced inputs from field wiring. ISM-TRM-ISO-OUT provides 24 lines of optically isolated outputs. Signal isolation between an embedded computer and monitoring points creates a barrier to eliminate common mode voltage and prevent ground loops on digital signals.
WinSystems; 817/274-7553; www.winsystems.com

MANUAL MODES

KL85xx digital and analog I/O manual operating modules provide manual machine intervention without opening the control cabinet. KL8519 with 16-channel, 24 Vdc digital inputs monitors machine status; KL8528 has eight-channel, 24 Vdc at 0.5 A per channel digital outputs to follow, disable or manually turn on outputs; KL8524 with four two-channel, 24 Vdc at 0.5 A digital outputs has eight channels in pairs such that only one output is allowed to be on at once; and KL8548 has eight-channel analog output, 0–10 V, and changeover between manual and automatic mode.
Beckhoff Automation; 952/890-0000; www.beckhoffautomation.com

POWER FOR FOUR

MX80 vision processor has an Intel Core i7 quad-core processor, with 4 GB memory and four independent Gigabit PoE ports for up to four unique camera inspections running in parallel. It runs Version 10.4 of Impact Software Suite with features that include a simpler interface and faster image-saving and image-filtering tools.
Datalogic/PPT Vision; 952/996-9500; www.pptvision.com

MICRO MILL

IndraMotion MTX micro compact CNC solution for standard turning and milling machines has a custom HMI and multi-axis drive controller with high-capacity CNC and PLC. It includes a comprehensive technology-cycle library for solving complex machining tasks; is compatible with the standard, performance and advanced versions of IndraMotion MTX; has preconfigured software for turning and milling; and has open PLC per IEC 61131-3.
Bosch Rexroth; 800/rexroth; www.boschrexroth-us.com

SMOOTH PATH AHEAD

Entry-level Sinumerik 808D CNC provides up to three-axis plus spindle control capability in milling or turning applications. Its 7.5 in. color LCD has 640x480 resolution, selectable function keyboard, rotary dials for speed and spindle override, LED tool

number display, durable buffer battery, and rear connection ports for USB, RS-232C, distributed and onboard I/O, as well as setpoint to feed axes and spindle, spindle encoder and fast I/O.
Siemens Industry; 800/879-8079;
www.usa.siemens.com/cnc

MULTI-AXIS LATHE

M70V for standard production machine applications such as grinding, turning, lathes, screw machines and gear hobbings includes high-end CNC features, high-speed PLC and nano control capabilities. In lathe format, it controls up to four spindles with a maximum of 11 axes and two part systems.
Mitsubishi Electric; 847/478-2100; www.meau.com

DO MORE THAN MILL

With TNC 640 milling-machine control, turning operations can be enabled on a milling machine, allowing the operator to transition from milling to turning cycles in the same program. The turning operations can be programmed in plain text for roughing, finishing recessing and thread cutting. A smartSelect selects cycles, and syntax color highlighting improves clarity for editing machining programs.
Heidenhain; 800/543-0192; www.heidenhain.us

EXTREME STOPS

Corrosion-resistant ZS71 and ZS91 emergency pull-wire switches for extreme environments in high-pressure/high-temperature wash downs (IP69K) have an integral e-stop button allowing optional e-stop operation directly at the switch. Each is available for ATEX/IEC Ex-rated Zone 1 and Zone 21 explosive environments.
Steute Xtreme; 203/244-6304; www.steutextreme.com

SOUND CONTROL

BSV Series audible indicators come with 15 pre-loaded, selectable alarm and chime-style sounds. Users can program each unit with 15 original messages or sounds in MP3 format totaling up to 63 s with an optional SD card. They provide user-selectable volume control 0–87 dB at 1 m.
Patlite; 310/328-3222; www.patlite.com

ENHANCED BRICK

Power Brick Drive has a seventh-generation PMAC controller integrated with upgraded amplifier blocks. It has vibration suppression of flexible mechanical systems, adaptive control of dynamic inertial fluctuations, automatic cross coupling, and on-the-fly inverse and forward kinematics computation of a six-axis actuator (robot) arm.
Delta Tau; 818/998-2095; www.deltatau.com

LOW-MAINTENANCE TYPE

Type ES actuator combines caged ball LM guide Type SRS and a rolled ball screw equipped with a QZ Lubricator. Type EC actuator also uses a rolled ball screw equipped with a QZ Lubricator in two models with widths ranging 40–48 mm and heights 48.5–57.5 mm.
THK America; 847/310-1111; www.thk.com

INDUSTRIAL TV

LX Series industrial-grade embedded PC-based monitor has modular steel construction in six sizes 32–70 in., industrial-type mounting and AC quick disconnect, and is Ethernet-ready. It offers a choice of industrial-grade embedded AMD Fusion or Intel Core motherboards, solid-state drive, and CPU options.
Dynics; 734/677-6100; www.dynics.com

A BRIDGE TO SAFETY

SafetyBridge distributes safe I/O modules in a network without a safety controller as the input and output modules exchange safety-related signals with one another. The modules process the safety function themselves, so the control system and network are used only as a transport medium. Safeconf software parameterizes the safety input and output channels and generates the safety logic. Pre-configured function blocks are available.

Phoenix Contact; 800/322-3225; www.phoenixcontact.com

FIVE AT A TIME

For simultaneous five-axis high-speed machining, 30i-B/31i-B5 CNCs have high-speed, smooth Tool Center Point Control (TCP) with fairing technology to reduce cycle times. Execution of common instructions is 2.5 times faster than the previous generation, with additional capability of high-speed module executing every 1 ms. It includes a handheld operator's unit iPendant for CNC.

Fanuc FA America; 888/326-8287; www.fanucfa.com

PID YOUR PLC

Eurotherm Mini8 multi-loop PID controller with EtherNet/IP communications partners with a PLC in multi-loop PID applications such as plastics extrusion, so the PLC can concentrate on providing faster, more effective logic control without the burden of running complex control algorithms. Input accuracy is ±0.1% or better.

Invensys Operations Management; 703/724-7300; www.eurotherm.com/ethernet-ip

CAN DO CAN

PCI/104-Express boards for use in compact industrial computers and mobile systems have up to four CAN interfaces and optional switchable high-/low-speed CAN and LIN interfaces. In addition to a passive version for cost-sensitive applications, an active version with a 32-bit microcontroller is offered. All interfaces are galvanic isolated by default.

Ixxat; 603/471-0800; www.ixxat.com

POWER AND BEYOND

Infinity power supplies provide the tighter output voltage regulation, and lower output ripple advantages of linear regulation technology. Line and load regulation for many models is 2 mV, and ripple less than 0.25 mVrms, 0.75 mVp-p with virtually no common mode noise. Standard models are available with outputs to 150 V and 150 W, with both slot output voltage ranges and wide-adjust models.

Acopian; 610/258-6149; www.acopian.com/infinity

CHECK YOUR VIBE

Vibconnect RF wireless condition monitoring system for machine components monitors machine vibration, bearing condition and temperature, and transmits data to the bridge for evaluation. It also detects damage caused by cavitation. Vibconnect bridge acts as the central receiver, and processes data from the sensor units and transmits it through the operator's network for visualization and archiving. The system includes a range of analytical functions to assess condition.

Ludeca; 305/591-8935; www.ludeca.com/vibconnect

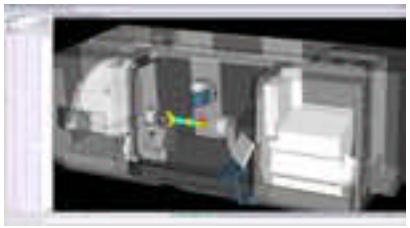
SOFTWARE

MACHINING SOFTWARE

XPS-GCode conversion software can read, convert and edit G-code, and execute in company's XPS Universal motion controller. It features a 3D display with a real-time, active-tool indicator; and generates smooth motion routines along optimized trajectories with controlled velocity. It can handle an array of high-precision machining processes, including laser machining.

Newport; 949/253-1247; www.newport.com/g-code

TRUE CUTS



Vericut 7.2 CNC machine simulation, verification and optimization software eliminates the process of manually proving-out NC programs. It simulates all types of CNC machine tools, and has the ability to optimize an NC program from a saved simulation. Users can adjust and re-optimize without rerunning the simulation.

CGTech; 949/753-1050; www.cgtech.com

SOFTWARE PAC

SoftPAC software-based programmable automation controller for computationally intensive applications and applications that must log, manipulate and exchange large amounts of data is programmed with the PAC Project software suite just like company's hardware PACs. Drawing on PC RAM, it can provide up to 64 MB RAM, and it runs under Microsoft Windows 7 (32-bit or 64-bit) or Windows XP (32-bit).

Opto 22; 800/321-6786; softpac.opto22.com

AD INDEX

control design
FOR MACHINE BUILDERS

is the only magazine exclusively dedicated to the original equipment manufacturing (OEM) market for instrumentation and controls—the largest market for industrial controls.

PutmanMedia®
555 W. Pierce Rd., Suite 301
Itasca, Illinois 60143
630/467-1300
Fax: 630/467-1124

PUBLISHING TEAM

GROUP PUBLISHER & VP, CONTENT
KEITH LARSON klarson@putman.net

DIRECTOR OF CIRCULATION
JACK JONES jjones@putman.net

SALES TEAM

NORTHEASTERN AND MID-ATLANTIC REGIONAL MANAGER
DAVE FISHER dfisher@putman.net
508/543-5172 Fax: 508/543-3061
24 Cannon Forge Dr.
Foxboro, Massachusetts 02035

MIDWESTERN AND SOUTHERN REGIONAL MANAGER
GREG ZAMIN gzamin@putman.net
630/551-2500 Fax: 630/467-1124
555 W. Pierce Rd., Suite 301
Itasca, Illinois 60143

WESTERN REGIONAL MANAGER
LAURA MARTINEZ lmartinez@putman.net
310/607-0125 Fax: 310/607-0168
218 Virginia, Suite 4, El Segundo,
California 90245

DIGITAL SALES SPECIALIST
JEANNE FREEDLAND
jfreedland@putman.net
805/773-4299 Fax: 805/773-0451

INSIDE SALES SPECIALIST
POLLY DICKSON pdickson@putman.net
630/467-1300 Fax: 630/467-1124

EXECUTIVE STAFF

PRESIDENT & CEO
JOHN M. CAPPELLETTI

CFO
JANE B. VOLLAND

VP, CIRCULATION
JERRY CLARK

VP, CREATIVE SERVICES
STEVE HERNER

REPRINTS

FOSTER REPRINTS www.fosterprinting.com
JILL KALETHA
jillk@fosterprinting.com
866-879-9144 ext. 168

Jack Chopper • jack.chopper@filamatic.com

The OEE Route

MANY YEARS AGO, during a Lean Manufacturing training session, I collected one of my favorite axioms: "If you change something before measuring it, you won't be able to determine if the change was an improvement."

The ideal process is to measure, make a single change, document, measure again. The key word is "single." But how many of us have the luxury of following that process for implementing changes? In production environments, I suspect very few.

As a controls guy, I like to measure and analyze. I also read everything I can get my hands on regarding best practices and overall equipment effectiveness (OEE) measurements and implementations.

Consider this question: Which road will get you to the 60 mile mark faster: Traveling 30 mph on a road with no traffic lights, or traveling 50 mph on a road with traffic lights every 4.75 miles on average, with each red light lasting an average 2.5 min?

To decide, many focus on the minimization problem and the rudimentary arithmetic, but what's described in this little exercise are the "ideal" conditions. We don't know the incidences of backups, the synchronization of the traffic lights, etc.

OEE is one tool that will help us make decisions, since we will understand the interrelationships of the various processes much more thoroughly.

Ditto that for dynamic plant conditions, where few processes are truly independent. Properly measuring the performance of one process requires isolating it from the others. When measuring dependent processes, it's important to analyze the interactions and relationships to identify and understand the root cause of changes in the metrics.

In the road case above, a simple change to the duration of a particular traffic light might benefit the overall throughput of traffic. Or changing such timings only during specific hours might be more beneficial. Quickly, we begin to envision the design of experiments to determine the best strategy for the automatic signals.

We need to arm ourselves with information that lets us make good decisions in a timely manner to reap the benefits. Example: The sooner we know that the widget machine is struggling, the sooner we can take action. This action helps us either to mitigate that particular issue, or better use labor and materials on all of the downstream equipment.

We know the widget machine is struggling because we measured it—whether it's output, fluctuations in power consumption, or whatever. We have a history of prior measurements with which to compare that data.

Back to the road example: Assuming there are alternative routes to use when traffic grinds to a standstill, many drivers begin a mental exercise to choose to stay on their current route, or to invest the time necessary to navigate to an alternate. With GPS devices supplying real-time traffic information, browser-enabled smartphones, and traffic boards that announce distance and estimated travel times, the exercise now involves much more data than before. Not so long ago, many of us relied solely on traffic reports from local radio stations.

The takeaway is that the "better road" will change from one to the other—and back—as conditions change. The time of day that the changes occur is crucial if we're to react appropriately.

Although far more complex than a simple road example, the same thought process applies to plant equipment and its performance data. Many of us are engaged in supplying solutions to help enterprises become more effective with the time available; we want more throughputs, with fewer errors and rejects, with far more precision than ever before. More importantly, we want to know when we're failing to meet those goals, but we want to know as soon as possible so that we can mitigate.

To reach those goals, we must make good decisions. Properly implemented, OEE is one tool that will help us make those decisions, since we will understand the interrelationships of the various processes much more thoroughly. With some OEE history, we will benefit from a predictive component, which is among the most valuable data.

By itself, OEE isn't enough. We need to create the culture where changes are embraced. At the end of the day, how fast the production lines ran is far less important than the throughput minus the rejects. OEE will give you the numbers, but the changes necessary to improve those numbers comes from—you guessed it—you. CD

JACK CHOPPER is chief electrical engineer at Filamatic (www.filamatic.com) in Baltimore.

Take a break from a week filled with questions, by attending a week filled with answers.

LISTEN.
THINK.
SOLVE.®

Learn about the latest smart, safe, sustainable solutions to optimize production. Improve machine performance. Get all the answers at Automation Fair® in Philadelphia, Nov. 7–8. Visit www.AutomationFair.com.

For the truly inquisitive, attend the Safety Automation Forum or Process Solutions User Group. Learn more at www.SafetyAutomationForum.com and http://psug.rockwellautomation.com.

Rockwell Automation
Automation Fair®
PHILADELPHIA 2012

Allen-Bradley • Rockwell Software

Rockwell Automation

SPEND LESS. Do more!

with the new supercharged Do-more™ PLC

If you've been using *DirectLOGIC* 205 PLCs, but you've been wanting ...

- ***More program memory***
- ***More and flexible data type memory***
- ***Faster program execution***
- ***Easier-to-use instruction set***
- ***Integrated Ethernet on the CPU***
- ***Faster I/O for counting and motion applications***
- ***More and easier-to-use communications***

... THE WAIT IS OVER!

The **new Do-more H2 series** CPUs leverage the existing line of DL205 I/O modules and base units to create an incredibly powerful PLC - at an incredible bargain.

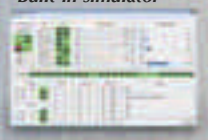
Two CPU options are available:

H2-DM1E	**$399**	(1) USB port for programming, (1) full-duplex serial port, (1) Ethernet port
H2-DM1	**$299**	(1) USB port for programming, (1) full-duplex serial port

- Over 1M bytes total memory *(includes program, data and documentation)*
- Program/monitor/debug over any embedded communication port.
- Supports up to 256 I/O locally and thousands more with optional Ethernet remote I/O.
- Supports inexpensive serial port expansion for connection to bar code readers, printers, etc.

And each Do-more CPU comes with a coupon for a 30-day free trial of online video training.

Built-in simulator



Program Do-more with the **completely new - and FREE - Do-more Designer software.** (***Direct****SOFT and ladder programs developed with* ***Direct****SOFT are not compatible with these CPUs.)* Download the **FREE** software!

Get started fast!

Choose a Do-more starter kit to get going fast. You get:

- Prewired, 3-slot base** with your choice of Do-more CPU
- 8-point input simulator module
- 8-point relay output module
- Do-more Designer software CD-ROM
- USB programming cable
- User manual
- **Coupon for 30 days FREE online video training**

** AutomationDirect reserves the right to substitute a larger base at its discretion

Starter Kit

H2-DM1E-START	**$626**	with H2-DM1E CPU
H2-DM1-START	**$536**	with H2-DM1 CPU

So visit ***www.do-moreplcs.com*** *for the details, watch overview videos, and download the free software to take it for a spin.*

Or go straight to:
www.automationdirect.com/do-more-plcs *to buy!*

www.automationdirect.com

Go online or call to get complete information, request your free catalog, or place an order.

1-800-633-0405

Order Today, Ships Today!

VOTED #1 Best in SERVICE 11 YEARS

AUTOMATIONDIRECT.com
the #1 value in automation